FINAL REPORT

Town of Acton
Nonpoint Source Control Program
Project 00-07/319

June 30, 2005

WOODARD & CURRAN
Engineering • Science • Operations

35 New England Business Center
Andover, MA 01810
(978) 557-8150

www.woodardcurran.com

Personnel Involved:

Authors:
Robert J. Rafferty, P.E., W&C

Project Managers:
Doug Halley, Town of Acton
Robert J. Rafferty, P.E., W&C

Quality Assurance Officer:
Helen Priola, P.E., W&C

DEP Project Officer:
Brian Duval and Jane Peirce, DEP

DEP 319 Program Coordinator:
Jane Peirce

EPA Quality Assurance Officer:
Arthur Clark, EPA

EPA 319 Program Coordinator:
Bruce Rosinoff, EPA

Town:
Town of Acton
472 Main Street
Acton, MA 01720

Consultant:
Woodard & Curran Inc.
35 New England Business Center
Suite 180
Andover, MA 01810

Governing Agencies:
Massachusetts Department of Environmental Protection
Bureau of Resource Protection
627 Main Street
Worcester, MA 01608

United States Environmental Protection Agency
60 Westview Street
Lexington, MA 02421

TABLE OF CONTENTS

SECTION **PAGE NO.**

LIST OF TABLES

TABLE	PAGE NO.

LIST OF FIGURES

FIGURE	PAGE NO.

APPENDICES

EXECUTIVE SUMMARY

The Town of Acton (the Town) proposed a Watershed Trading Program as part of an Environmental Protection Agency (EPA) National Pollution Discharge Elimination System (NPDES) permit to discharge treated wastewater effluent to the Assabet River. The focus of the effort was to model the impact of non-point best management practices (BMPs), both structural and nonstructural, on phosphorus loading to surface waters in Acton to offset the phosphorus to be discharged through the NPDES permit. Ultimately, the Town's treatment facility received a permit to discharge to infiltration basins, not directly to the Assabet; but the NPDES permit has strict phosphorus limitations that reflect the importance of limiting the ability of phosphorus to reach the Assabet River.

The Town subsequently received federal funds from the EPA, through the Massachusetts Department of Environmental Protection (MADEP), under an s.319 competitive grant to conduct a pilot study of BMP alternatives. According to the EPA grant scope documents, "This project is intended to pilot watershed trading programs that will become increasingly important and common in the coming years as communities strive to meet new NPDES requirements."

The project scope consists of two efforts. Part A – Watershed Trading is comprised of an evaluation of drainage outfalls and construction of two outfall BMPs (best management practices) for phosphorus reduction. Part B – Recirculation Pond is comprised of an evaluation of runoff at the North Acton Recreation Area (NARA) swimming pond, and construction of a re-circulation pond (wetland) system to reduce phosphorus in the swimming pond.

The project also assesses town practices related to stormwater control. Department heads were interviewed for stormwater related practices, such as street sweeping, catch basin cleaning, and fertilizer application. The project team developed recommendations that have become the foundation for the Town's Stormwater Management Program. The grant also includes public education and outreach efforts, communicating the impacts of excess phosphorus and the methods that can be used to control or limit phosphorus in surface waters.

The evaluation phase of Part A revealed that the grant's funds would be better applied to a focused effort at the constructed wetland. The sampling program did not provide suitable quantity or quality of data to justify the construction of control structures at the outfalls. Furthermore, the outfalls that exhibit measurable nutrient concentrations directly discharge to wetlands, minimizing the worth of a stormwater structure (BMP) to the Assabet River and its tributaries. Instead, the project was redirected to increase the data gathering effort at the constructed wetland (recirculating pond) and increase the public education component to construct a viable long-term BMP.

The constructed wetland at NARA has become a focal point for wildlife, with a wide variety of plants and animals residing in the wetland, and for park visitors who can observe the wetland from walking paths. Additionally, an environmental educational program has been created that includes educational kiosks and an interactive program taught during summer camp. Most importantly, the expanded sampling program has indicated that the wetland serves its intended function of phosphorus removal under most circumstances, in addition to removing measurable amounts of nitrogen and solids. This is important to the long-term health of the swimming pond to prevent future potential problems from excessive aquatic growth in the pond and protecting the pond from road and parking lot sand and sediment.

1. INTRODUCTION

1.1 BACKGROUND

The Town of Acton (the Town) proposed a Watershed Trading Program as part of an Environmental Protection Agency (EPA) National Pollution Discharge Elimination System (NPDES) permit to discharge treated wastewater effluent to the Assabet River. The focus of the proposal effort was a reduction in phosphorus loading to surface waters in Acton to offset wastewater effluent discharges.

The goal of the watershed trading program was to demonstrate whether sufficient phosphorus could be removed from non-point sources to offset the phosphorus planned to be introduced via point source discharge of the proposed Acton wastewater treatment facility. The program proposed to conduct calculations of overall non-point phosphorous loading in Acton and modeling of existing conditions, assessment of best management practices (BMPs), and modeling of the impact BMPs would have on overall phosphorus loading from non-point sources. BMPs could include structural end-of-pipe solutions and nonstructural solutions such as employing procedural systems (street sweeping improvements for example) to limit discharges.

However, a NPDES permit was issued that requires land discharge of treated wastewater effluent. The permit limits phosphorus discharges to 0.2 mg/l as a monthly average, which reflects the importance of limiting phosphorus loading on the Assabet River and other surface water. Subsequently, the Town applied for and received federal funds from the EPA, through the MADEP, under an s.319 competitive grant to conduct this pilot study of alternatives. This report present the results of the Watershed Trading Program financed through the s.319 grant program.

The project consists of two parallel efforts to construct structural BMPs, joined through non-structural BMPs such as public education and outreach. Part A – Watershed Trading, is comprised of an evaluation of drainage outfalls for construction of two outfall BMPs for phosphorus reduction. Part B – Recirculation Pond, is comprised of an evaluation of runoff at the North Acton Recreation Area (NARA) swimming pond, and construction of a re-circulation pond (wetland) system to reduce phosphorus.

2. SCOPE AND ACTIVITIES

2.1 OVERVIEW / HISTORY

The project began in 2001 with the evaluation of outfalls town-wide for construction of best management practices (BMPs) and concurrent planning for the construction of the wetland BMP at NARA. Section 3 provides specifics of outfall selection (Part A of the grant scope). Section 4 contains the discussion of the recirculation pond (constructed wetland) program (Part B of the grant scope).

2.2 SUMMARY OF ACTIVITIES

The grant requires delivery of a final report that includes a description of all activities undertaken as part of the project. Table 2-1 provides a summary of the project activities, with the status of each task, and references to specific information. The summary includes references to scope and schedule changes that are discussed in more detail in forthcoming sections.

Table 2-1: Summary of Project Activities

Task	Task Status	Reference / Deliverable
Part A – Watershed Trading		
A1 – QAPP and Water Quality Monitoring	QAPP submitted to DEP; reviewed and approved in October 2002. QAPP amended March 31, 2005.	A1.A – The QAPP was submitted to DEP under separate cover. Amended QAPP has been forwarded to DEP. A1.B – Appendix A includes the sampling results. Analytical reports and results are discussed and tabulated in Section 3 and Section 4.
A2 – Structural BMP Site Selection	Selected 17 sites for review, followed by evaluation of 10 sites. Submitted report. Sampled 5 sites, resulting in an approved scope change.	A2.A – Refer to Section 3 A2.B – Refer to Section 3
A3 – Design and Construct Watershed Trading Program BMPs	Scope change	Refer to Section 3
A4 – Operations and	Scope change	Refer to Section 3

Task	Task Status	Reference / Deliverable
Maintenance Plan		
A5 – Watershed Trading Program Non-structural BMP Program	The implementation of many scope items has been included in the Town's NPDES Phase II Stormwater Management Program. The scope of this grant was modified to augment the Phase II requirements, but not to duplicate or satisfy the Phase II plan. A5.A – The review of current practices is complete. A5.B – The project team developed recommendations for policy and practice improvements that formed the foundation of the NPDES Phase II Stormwater Management Program Good Housekeeping section. A5.C – Refer to Task A5.B A5.D – Interviews with Town staff are complete. A5.E/F – Outreach materials include survey, which was distributed during Acton Days at NARA in 2003 and is available at an information table in Town Hall. Minimal participation resulted in statistically irrelevant data. Scope changed to include an additional kiosk, teaching amphitheater and summer camp curriculum under Task B – Recirculation Pond.	The Town's Stormwater Management Plan (and BMP manual) is located at: http://doc.acton-ma.gov/dsweb/Get/Document-8087/Stormwater+Plan.pdf A5.A – Meeting minutes and the letter to DEP dated May 31, 2002 are included in Appendix B A5.B – Refer to the letter to DEP dated May 31, 2002 included in Appendix B. See the Town's web site for implementation measures conducted under Phase II. A5.C/D – Comprehensive Stormwater Manual is included in NPDES Phase II NOI manual. A5.E – Refer to Section 3. Appendix C includes education materials, including the survey form, kiosk plans, and summer camp curriculum excerpts. A5.F – Refer to Section 3.
Part B – Recirculation Pond		

Task	Task Status	Reference / Deliverable
B1 – QAPP and Water Quality Monitoring	Combined with Part A1	See Part A1
B2 – Pond Recirculation System Design and Construction	Construction of the wetland is complete.	B2A – Refer to the original grant proposal and MIT report included as part of the 319 RFR response, March 1999. The grant proposal included the construction layout and pond configuration B2.B – N/A The entire NARA area is part of a Conservation Commission NOI B2.C – Photographs and construction drawings are attachment in Appendix D. B2.D – The wetland was constructed in accordance with the general guidelines and configuration of the MIT report.
B3 – Pond Recirculation Project Manual	This is the Draft Report/Manual	Refer to Section 3

3. PART A – WATERSHED TRADING

3.1 OUTFALL SELECTION

The Project Team developed a screening process to review outfalls and identify sites that may benefit from structural BMPs. The specifics of outfall selection are detailed in the report, ***Draft Report on Watershed Trading Program Structural BMP Site Selection***, dated April 2002, attached as Appendix E. The report outlined the site selection process used for determining feasible locations for structural BMPs. The selection process was iterative in that the types of structural BMPs that are implementable at each site are dependent on the site characteristics. Therefore, the project team conducted four rounds of screening as detailed in Appendix E, which included:

1. Initial selection based on available drainage, surface water, and land-use mapping; knowledge of town staff; and a windshield survey of the drainage system.

2. After the first round of screening, the Project Team selected the seventeen sites shown in Figure 3-1 for preliminary evaluation. The initial seventeen sites were inspected and re-evaluated based on potential impact downstream and to gather information to compare the outfalls for potential BMP installation

3. We developed a Site Selection Matrix (SSM) to focus the evaluation efforts on the most promising ten sites. The SSM contains comparison criteria used to rank the ten sites for further analysis. Photographs of the ten sites are included in Appendix E.

4. The SSM criteria ranking was refined after follow-up site inspections to select the most promising five outfalls. The final SSM is included with the report in Appendix E.

We chose five outfalls for baseline monitoring in accordance with the procedures outlined in the Quality Assurance Project Plan (QAPP). The five sites are:

1. Horseshoe Drive
2. Kelley Corner
3. Larch Road
4. Quaboag Road
5. Wetherbee Street

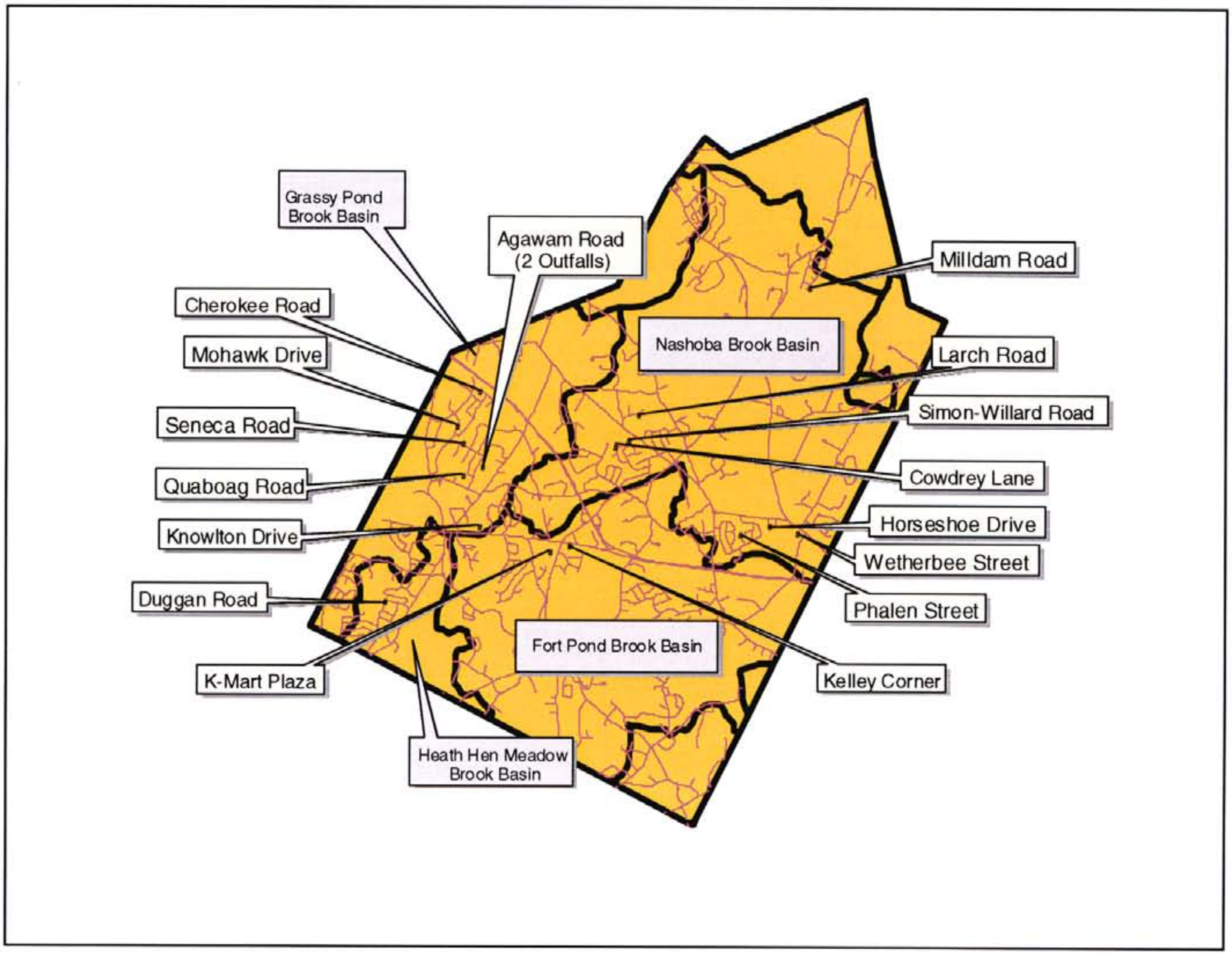
Locus maps and photographs of the five outfalls are included in Appendix E.

3.2 SITE SELECTION FINDINGS

The primary function of the existing drainage systems is to provide drainage for wet areas and to convey surface runoff away from areas of human use such as homes, yards, and streets. Much of the drainage system in the Town was constructed through the programs of the Works Progress Administration (WPA) in the 1930's. During this period drains tended to follow the most direct drain route to unbuildable land without much regard for the impacts on the receiving waters. Only recently in the State's construction history have stormwater detention basins and other structures been incorporated into common use to protect the receiving waters from the direct impacts of stormwater (sediment, nutrients, pollutants, etc.).

Many of the structural BMPs outlined in technical fact sheets and reports by MADEP, the EPA, and the Center for Watershed Protection, or studies conducted by colleges and universities tend to focus on treating stormwater produced from new developments or retrofitting drainage structures for solids removal. This project's intent is to retrofit existing drainage systems with structural BMPs specifically for phosphorus reduction. The challenges lie in the limitations of the sites such as available space near outfalls, access for construction or O & M equipment, available head loss between an outfall and its receiving water (since outfalls tend to be placed at the edge of streams and wetlands), as well as the limited number of potential technologies available for retrofitting.

Figure 3-1: Acton, MA Stormwater Outfall Locations



The selection of drainage outfalls suitable for this demonstration project was unexpectedly limited given the over 100 drainage structures existing on public property in the Town. The older, 1930 vintage drains are generally located at, or close to, the normal (dry weather) groundwater level. Consequently, there is a reduced probability that sampling will be consistently successful because the drainage structures may be submerged. Additionally, many of these older systems are channeling existing streams instead of providing passage for surface runoff.

3.3 QUALITY ASSURANCE PROJECT PLAN

In April 2003, the project team submitted the Quality Assurance Project Plan (QAPP), which provided the procedures and protocols for sampling collection, handling, and analysis. The team recommended that the scope be altered based on MADEP's review comments.

The Project Team and MADEP met to discuss the project. MADEP agreed to omit the preconstruction sampling, but through subsequent discussion, MADEP and the project team agreed to conduct preliminary sampling to confirm the outfall selection. Pre-construction and Post-construction samples are limited to Nitrate-N, Total P, TSS, and flow.

3.4 SAMPLING PROGRAM RESULTS

The project team attempted to sample stormwater at the five outfalls and at the recirculation pond in 2003. The sampling program focused on first flush samples, which are defined by the Quality Assurance Project Plan (QAPP) as a precipitation event during which at least 0.3 inches of rain is measured at an area monitoring station after a dry period of at least 72 hours. However, we obtained erratic data from most of the targeted drainage outfalls. The outfall at Wetherbee Street never flowed, so no data are available.

Table 3-1 shows that flow is not consistently available during the QAPP defined first flush, and the data are inconclusive where samples were obtained during both rounds.

Table 3-1: Outfall Pre-Construction Phosphorus (P) Sampling Results

Sampling Date:	18-Jun-03				2-Sep-03			
Daily Rainfall:	.36 inches				.78 inches			
Sample Location	Concentration (mg/l)	Flow (lps)	Flow (gpm)	**P (ppd)**	Concentration (mg/l)	Flow (cfs)	Flow (gpm)	**P (ppd)**
Kelly 8"	-	-	-	-	0.232	0.003	1.35	**.00375**
Kelly 30"	0.11	230	3,646	**4.82**	-	0.72	323.14	-
Larch 12"	0.07	0.018	0.29	**.00024**	0.03	0.067	1.06	**.00038**
Horseshoe	0.06	186	2,948	**2.13**	-	1.03	462.26	-

ppd = pounds per day; mg/l = milligrams per liter; lps = liters per second; gpm = gallons per minute; cfs = cubic feet per second

We extrapolated the concentrations and flows from instantaneous values to calculate mass loading values (in pounds per day) for comparison purposes only, recognizing that accurate values for mass loading used for BMP design should not be calculated from individual grab samples. Mass loadings should be calculated from geometric means of many more sampling data points.

In some outfalls (Quabog and Wetherbee Street) flow was nonexistent during the sampling rounds or nutrient levels were extremely low. Storm water flow was erratic at all other outfalls except at the Larch Road 12-inch pipe, which is essentially a re-directed stream. Therefore, the data are not sufficient to conclude that construction of BMPs at the selected locations would be beneficial. Furthermore, the outfalls that exhibit measurable nutrient concentrations directly discharge to wetlands, minimizing the worth of a BMP to the Assabet River and its tributaries.

3.5 WATERSHED TRADING CONCLUSIONS

We could not reliably select outfall sites for construction of BMPs based on available data. Construction of BMPs without valid data justifying the installation would not apply the grant's funds as intended. Further sampling would be needed to justify BMP construction and to establish a valid baseline for loads. However, the grant's funds do not support additional sampling and construction of BMPs at multiple outfalls. Therefore, continued evaluation of the outfall BMPs was suspended to focus on the recirculation pond.

Despite this, we have obtained valuable insight useful to others interested in this type of program.

- First, the number of outfalls with potential direct impact to local streams and the Assabet is very limited given that most outfalls discharge overland or to wetlands.
- Second, the percentage of outfalls conducive to installing BMPs for phosphorus reduction at the outfall is very small because of many factors including available headloss, downstream impact, accessibility, and available land area. This is discussed in detail in the *Draft Report on Watershed Trading Program Structural BMP Site Selection* (April 2002) and shown in the SSM included in Appendix E.
- Third, there are inherent problems with short-term sampling programs. Sampling programs that target first flush with grab samples are very erratic. More frequent sampling events that focus on one location may provide a better baseline. Future programs should budget for many more rounds of data gathering and possibly continuous sampling. Additional (budgeted) time is needed to account for the variations in land uses that cause variable first flush times for different sampling locations. First flush sampling as defined in the QAPP is more effective for sampling locations with comparable upstream land uses, where the time of concentration within the drainage area can be predicted accurately, and minimal staff time can be budgeted for the sampling effort.

3.6 WATERSHED TRADING RECOMMENDATIONS

While the sampling program selection did not provide candidates for outfall BMPs, the basis of selecting the NARA site for the recirculation pond is well established. As described in the original grant application, the NARA swimming pond historically experiences high nutrient levels, specifically phosphorus, of approximately 0.04 mg/L. The intent of the constructed wetland is to mitigate the phosphorus levels in runoff from the direct drainage structures surrounding the pond. This BMP is justified based on the historical data and for educational and demonstration opportunities.

We recommended, and DEP concurred, to re-allocate the budget categories to allow the Town to focus on completing the constructed wetland, which has already become a featured attraction at NARA, and enhancing the original scope instead of constructing outfall BMPs of questionable worth. The NARA wetland scope was changed to conduct an additional three rounds of sampling because the two rounds conducted did not provide useful data.

We proposed that grab sampling be continued, but more frequent rounds of sampling be conducted under wet weather and snow melt conditions. We added samples from the swimming pond to evaluate whether short-term monitoring of phosphorus in this manner could be used for comparison to historical data.

Focusing on the wetland also allowed us to shift the public education and outreach component of the grant to feature construction of a small teaching amphitheater and development of an environmental component to the NARA summer camp program under the leadership of the Acton Natural Resources Department. Other improvements included improving handicap access and adding diverse plantings.

4. RECIRCULATION POND PROJECT MANUAL

4.1 WETLAND DESCRIPTION

The NARA wetland demonstration site is characterized by three segments, with water elevation controlled by weirs between the segments. A walkway crosses the wetland at the weirs, providing opportunity for close observation of the wetland. Stormwater enters into the upper pool from two reinforced concrete pipe (RCP) outfalls, and one PVC pipe. An onsite bedrock well, which discharges through a rock swale into the upper segment, provides recharge flow to offset evapotranspiration losses.

When the upper pond reaches an appropriate overflow depth, flow continues over weir #1 and splits into two meandering channels that feed into a pool above weir #2. Once the second pool reaches an appropriate overflow depth, flow continues over weir #2 through a rock channel (150 feet long) before entering an 18-inch RCP, which then discharges to the micro-pool at the northern section of the swimming pond. An overflow berm between the micro-pool and the swimming pond allows some percolation of water through the berm.

Appendix D contains photographs of the wetland and the AutoCAD plan of the wetland. The photographs were taken prior to installation of the education boards but they show the final grading and plantings. Table 4-1 describes the inlets to the wetland.

Table 4-1: Inputs to the Constructed Wetland / Recirculation Pond

Inlet	Size / Description	Tributary Area
Inlet 1	16-inch RCP	50-70 acres of Town Forest and 2 catch basins in Quarry Road
Inlet 2	15-inch CMP	Parking lot precipitation greater than 1-inch, walkway and entrance/service road
Inlet 3	6-inch PVC	Main amphitheater groundwater and roof leaders
Well Pump	Rock-lined swale – 2-feet wide	Up to 5 gpm pumped groundwater

The MIT report, *North Acton Recreation Area Wetland Project*, which is the basis of the wetland design, recommended that a pump be installed in the micropool that would feed water to the pond inlet, offsetting the evapotranspiration of the wetland surface water. The pump was not sized to recirculate enough pond water for measurable phosphorus treatment. We have installed a well pump instead, which creates a more reliable system by avoiding several potentially significant operational problems, such as clogging from aquatic plants, access for maintenance, shutdown for cold weather, and potential tampering. The well is equipped with a time to adjust flow and produces approximately 5 gallons per minute, which will offset the expected loss of 1.75 gpm, as calculated in the MIT report.

The MIT report provides a background discussion on the expected phosphorus removal mechanisms, which include sedimentation, soil adsorption, microbial metabolism and plant uptake. However, plant uptake can be seasonal, returning phosphorus and other nutrients through decay because the Town does not harvest the plants.

Town staff planted the wetlands buffer zone in the spring of 2002, which was followed by one of the driest summers in recent years. A number of the plants died. But since 2002, plants are thriving in and around the perimeter of the wetlands, including swamp rose, azalea species, trembling aspen, black birch, river birch, pussy willow, cornus mas, ilex glabra, sweet fern, clethra, ginko biloba, and cattails and other aquatic species.

4.1.1 Operation

During dry weather and light rainfall, the flow through the wetland usually percolates to the subsurface by the end of the second stage of the wetland, never reaching the outfall pipe. Our second round of sampling on April 24, 2005, which followed 22 days of relatively dry weather, showed more flow entering the wetland than exiting the wetland, which could indicate subsurface flow. Through this mechanism, the wetland is performing its intended function of intercepting nutrients and suspended solids. Because subsurface flow is the default condition (occurs the majority of the time) our challenge was to evaluate the wetland under extreme, and less frequent, conditions.

During extreme high flow periods such as on April 2, 2005, which occurred during high groundwater periods and snowmelt and a large rainfall event, the outfall to the micropool is submerged and the outfall pipe is surcharged, causing some flow from the wetland to travel overland to the micropool and swimming pond. During this condition, the ground is saturated and inlet flow should approximate outlet flow.

The subsurface drain (Inlet 3) from the Town's large amphitheater area provides the most consistent flow to the constructed wetland. The pre-construction sampling obtained samples only from Inlet 3. The other surface drains do not flow without rainfall during the later summer months or after periods without precipitation. Without a consistent flow, such as from the amphitheater drain and the well system, consistent plant growth and a sustainable constructed wetland would be a considerable challenge. The bedrock well is operated by a timer, which will be adjusted to maintain consistent recharging of the wetland.

4.1.2 Public Education and Outreach

To augment the public education and outreach component of the project, and to reflect the shift in focus to the wetland, the Town constructed a handicap accessible walkway and small teaching amphitheater at the wetland. The teaching amphitheater is situated near the midpoint of the wetland. It consists of two seating layers constructed from granite blocks arranged in a semi-circle facing the wetland.

A series of five educational stations are located along the walkway that follows and crosses the wetland. Appendix C shows the educational sign layouts for the kiosks. The photographs in Appendix D show the observation/kiosk locations, though the panels were not installed when the photographs were taken. The five stations develop themes related to the wetland. The themes are:

1. The NARA Wetland Project – Presents the ABC's of the wetland showing the wetland's place in the watershed and gives an overview of the wetland's purpose.

2. History of the Wetland Site – Describes the history of the NARA site before the swimming pond was constructed. Informs visitors that the constructed wetland helps to replace a smaller wetland that was flooded when the swimming pond was created.

3. Water quality – Describes nonpoint source pollution and how the wetland helps to control pollution.

4. What Can You See? – Discusses the various organisms in the wetland and the food web of the organisms.

5. What is a Wetland? – Provides a definition of a wetland and describes hydric soils and the various types of wetland plants.

Excerpts from the summer camp curriculum that specifically focus on the wetland are included in Appendix C. The initial summer camp curriculum was developed independently of the 319 grant program, but was dovetailed with the goals and results of this project. The curriculum is adaptable as the NARA site continues to change.

In 2003, the Town created a Nature Director position for the NARA summer camp who has been responsible for implementing water quality studies and pond/wetlands studies based on recommendations made by the biologists working primarily on the 319 grant. Children from 4 years of age to 14 take part in the program. New material will be included this year making use of the five new educational panels that we are installing.

The Natural Resources Department will ultimately be responsible for maintaining the health of the wetlands. Each spring a group of students removes accumulated trash from the wetlands under the direction of the department. This spring, ten students from the high school senior class worked at NARA on April 29 as part of their community service program.

4.2 DOCUMENTATION OF EFFECTIVENESS

Because the two rounds of preconstruction testing were inconclusive, post construction sampling was increased to three rounds. We conducted three rounds of sampling in spring 2005. Appendix A includes the summary tables, calculation sheets, and laboratory reports for all sampled parameters (phosphorus, nitrogen, and total suspended solids).

4.2.1 Flows

We conducted our post-construction sampling during wet weather events to increase the probability of flow at all sampling points and to evaluate the wetland under extreme operating conditions. All inlets were flowing during the three large events. The runoff from the precipitation events flooded the wetland, which minimized the potential for measurable treatment at the outlet. Very heavy rainfall events, such as April 2, 2005, partially submerge Inlet 3, which precluded direct flow measurement. During the spring season, the exit point of outfall pipe is submerged in the micro-pool, so samples were obtained at the entrance to the outfall pipe. However, on April 2, 2005 the outfall pipe was surcharged, causing overland flow.

The accuracy of the measurements is also variable. Inlet 2 in particular was very difficult to measure because of the nearly sheet (very shallow) flow. Our method of flow calculation (Manning's open channel flow equation or flow equals velocity times area) was dependent on the available information. Where possible we correlated the methods to verify the results. Table 4.2 provides our estimates of flows during the sampling events. Appendix A contains the detailed calculations and the field notes that discuss the flow measurements.

Table 4-2: Post-construction Wetland Flows (gpm)

Date	Rainfall (in. per day)	Inlet 1	Inlet 2	Inlet 3	Total Inlet	Outlet	Percent Flow - Inlet through Outlet
April 2, 2005	0.90	1,705	21	153	1,879	1,879	100%
April 24, 2005	0.59	1,705	7	78	1,790	1,167	65%
April 27, 2005	0.37	576	7	49	632	573	90%

During the April 2 storm the wetland overflowed. We assumed the subsurface was completely saturated resulting in actual outlet flow equal to the inlet flow. The April 24 storm followed a dry period, so much of the flow could have returned to the subsurface. April 27 followed the previous storm by three days and much of the subsurface could be saturated, resulting in 90% of the inlet flow being channeled through the outlet pipe.

4.2.2 Wet Weather Sampling

In cases where multiple inlets were flowing the total inlet concentration is calculated a weighted average of the concentrations. In some cases, measured concentrations were below the reportable detection limit, which makes direct calculations of removal effectiveness impossible. These samples are shown in the following tables as BRL (below reportable limit). We inserted "NS" in the tables where samples were not obtained.

However, we can estimate the baseline removal effectiveness under the sampled extreme conditions by calculating the removal percentage assuming minimal removal. Minimum removal assumes minimal inlet concentrations and maximum outlet concentrations. To minimize the inlet concentration, we assign a concentration well below the reporting limit to samples with concentrations reported as BRL. When the outlet has a concentration reported as BRL, we assume the concentration is at the reporting limit.

We conducted this approximation only when we had measurable concentrations from the largest flow contributor, Inlet 1, which contributes flow an order of magnitude greater than the other two inlets combined. Otherwise, we considered the results inconclusive.

Phosphorus

The pre-construction and post-construction sampling results for phosphorus are presented in Table 4-3.

Table 4-3: Wetland Pre and Post-Construction Sampling Results for Phosphorus

Sampling Date	Rainfall (in. per day)	Total Inlet Concentration (mg/l)	Total Outlet Concentration (mg/l)	**Removal**
Pre-construction				
June 18, 2003	.36	BRL	NS	-
September 2, 2003	.78	.069	NS	-
Post-Construction				
April 2, 2005	.90	.085	.024	**72%**
April 24, 2005	.59	.014	.025	**N/A**
April 27, 2005	.37	.007	.038	**N/A**

The recirculation pond (wetland) appears to be removing over 70% of influent phosphorus during the first sampling event, despite the minimal retention time caused by excessive flows. However, the next two sampling events showed a net gain of phosphorus. We further evaluated the data by converting the concentrations to a loading value (pounds per day) to account for the difference in flows between the inlet and outlet. There is no impact to the analysis because the loading values still show a net gain of phosphorus. For April 24 the net gain is 0.04 pounds per day (ppd) from an inlet loading of 0.031 ppd, while for April 27, the net gain is 0.21 ppd from an inlet load of 0.05 ppd. The wetland could be losing phosphorus due to sediment release and new growth loss from flushing, but we do not have confidence in the overall results due to the difficulty obtaining accurate flow measurements.

These results do not represent the typical wetland operation where the wetland detains the runoff and stormwater often percolates prior to the surface outfall. We would expect better removal if the retention time in the wetland was extended.

Nitrogen

Table 4-4 presents the sampling results for nitrogen as N.

Table 4-4: Wetland Pre and Post-Construction Sampling Results for Nitrogen

Sampling Date	Rainfall (in. per day)	Total Inlet Concentration mg/l	Total Outlet Concentration (mg/l)	**Removal**
Preconstruction				
June 18, 2003	.36	2.43	NS	-
September 2, 2003	.78	.18	NS	-
Post-Construction				
April 2, 2005	.90	N/A	N/A	-
April 24, 2005	.59	.107	BRL – 0.1	**6%**
April 27, 2005	.37	.114	BRL – 0.1	**12%**

Nitrogen samples could not be evaluated on April 2 because of sample holding times. On April 24, the major inlet did not exhibit nitrogen above the reportable limit, so the extrapolation of inlet concentration is beyond our confidence in the data. The subsequent two samples show nitrogen at below reportable limits (not detected) at the outfall

Total Suspended Solids

Table 4-5 presents the sampling results for total suspended solids (TSS) assuming this scenario.

Table 4-5: Wetland Pre and Post-Construction Sampling Results for TSS

Sampling Date	Rainfall (in per day)	Total Inlet Concentration mg/l	Total Outlet Concentration (mg/l)	**Removal**
Preconstruction				
June 18, 2003	.36	BRL	NS	-
September 2, 2003	.78	BRL	NS	-
Post-Construction				
April 2, 2005	.90	31	BRL – 5	**84%**
April 24, 2005	.59	BRL	8	**N/A**
April 27, 2005	.37	BRL	BRL	**N/A**

Inlet 1 exhibited measurable TSS post-construction, but only during sampling round one. When inlet TSS was measurable, we estimated a removal effectiveness of about 84%. The next round of sampling did not measure TSS above the reportable limit from the inlets, but the outlet sample contained 8 mg/l. Resuspended sediment or floating plant matter in the sample could have contributed to the elevated TSS level from this sampling event. However, the effectiveness of the wetland to remove TSS is evident by the lack of sediment in the micropool near the wetland's outlet.

Swimming Pond Phosphorus

We collected random grab samples from the swimming pond during the sampling rounds to provide a measure of comparison with the wetland's phosphorus discharge. Table 4-6 displays the phosphorus concentrations in the swimming pond from three post-construction sampling rounds.

Table 4-6: Phosphorus Concentrations in Swimming Pond

	Swimming Pond P (mg/l)	Wetland Outlet P (mg/l)
April 2, 2005	.024	.024
April 24, 2005	.076	.025
April 27, 2005	.035	.038

While this effort was not an exhaustive or comprehensive evaluation of the swimming pond's phosphorus level, it does show that the swimming pond's phosphorus level mirror's the wetland's outlet concentration and, except for the mid-round of sampling, is below the threshold of 0.04 mg/l established for this project. The higher level of phosphorus on April 24, 2005 appears to be short-lived, which may indicate that short-term upsets do not permanently affect the swimming pond.

5. CONCLUSIONS AND RECOMMENDATIONS

The investigation of the drain outfalls for the suitability of BMPs (Part A) showed that siting end-of-pipe treatment technologies in existing drainage systems might not be the most desirable alternative. Most end-of-pipe solutions require available land area, available headloss, accessibility, and other criteria as itemized on the site selection matrix. Construction of end-of-pipe BMPs is more suitable for new construction of new drainage systems, where many of the limiting factors inherent in existing systems can be corrected without extensive disruption.

For areas with existing drainage systems, source reduction and treatment may be more economical and buildable. Systems that retain or delay peak runoff at the source, such as rain barrels or cisterns, may provide solutions that end-of-pipe systems are not able to provide.

As discussed in Section 3.4, sampling programs should be greatly expanded to measure pre-construction conditions and post-construction effectiveness to provide a complete data set that can be the basis for concrete conclusions. A more long-term sampling program may provide more data suitable for an assessment of the average treatment provided by the wetland.

Unlike the drainage outfalls, the NARA site is a suitable location for the construction of an end-of-pipe BMP because:

- The receiving water (the swimming pond) has a documented problem with elevated phosphorus.
- The wetland is at an accessible location.
- The site has the drop in elevation (available headloss) and land area suitable for an end-of-pipe solution.

By observation, the recirculation pond (wetland) exhibited an ability to remove phosphorus, nitrogen, and TSS during dry periods because the flow through the wetland percolates to the soil prior to the final discharge point. During the initial round of wet weather sampling, which had surface discharge flow, the wetland was effective at removing the nutrients and suspended solids.

Wet weather events that occur during a plant-growing period may wash out material containing phosphorus. However, the sampling data is inconclusive and a much more exhaustive sampling program should be conducted to understand the wetland's dynamics under wet weather conditions. Our limited samples from the swimming pond may show that the swimming pond can recover from any short-term phosphorus loading during wet weather events in the spring growing season.

5.1 VALUE OF THE CONSTRUCTED WETLAND

In addition to intercepting nutrients and suspended solids, the wetland also provides ancillary benefits to the community. The wetland supports native wetland plants, and attracts insects, birds, and small animals such as a variety of frogs and snakes, which are readily observable.

One of our highest priorities for the wetlands and surrounding buffer was to create a wildlife corridor through a very landscaped and popular park. A pair of spotted sandpipers is nesting in the gravel near the upper pond; in addition, song sparrows are also nesting the same area. Because the upper pond has become such a successful breeding area for green frogs and American toads, great blue herons feed there.

Many of the buffer zone plants are three to four years old; thus, the wetland edges have filled in, creating a diverse ecosystem.

The NARA site is a destination for Acton residents, especially in the summer. The wetland's location between the swimming beach and the amphitheater makes the wetland a natural gathering place. The series of large stone blocks forming the walkway edges not only act as safe and unobtrusive barriers, but provide convenient seats and observation platforms.

The wetland is a teaching tool used as part of an interactive developed curriculum through passive education provided by the informational kiosks, and through interactive play and exploration. The handicap accessible trail and bridges attract visitors to the educational kiosks. The wetland provides an interesting opportunity for continued study; Acton's Health Department plans to conduct further sampling to augment the findings of this program.

The NARA constructed wetland is accessible and obvious, instead of hidden and situated away from pedestrian traffic, to encourage exploration and interaction. Construction of an interactive BMP such as the NARA wetland at open and accessible locations can provide a multi-purpose benefit for any community interested in effective treatment, restoration, and education.

5.2 ACKNOWLEGDEMENTS

MADEP/EPA provided invaluable guidance regarding the grant program operations, QAPP format and expectations, and general project assistance. This project's initial scope was largely based on a "bird's eye" view of the site conditions. The project had built in assessments of actual conditions to verify the initial assumptions. These assessments revealed site conditions that were sometimes vastly different than initially expected. The MADEP/EPA staff recognized this possibility, and worked with the Town of Acton's project team to adapt to the actual conditions and develop the most effective program possible

APPENDIX A: SAMPLING PROGRAM DATA AND CALCULATIONS

Woodard & Curran, Inc.

35 NEW ENGLAND BUSINESS CENTER
SUITE 180
ANDOVER, MASSACHUSETTS 01810
978-557-8150 • 1-866-702-6371
FAX 978-557-7948

CLIENT	Town of Acton, MA		
PROJECT	s.319 Grant Project		
DESIGNED BY	RJR	DATE	06/23/05
CHECKED BY	EJF	DATE	06/23/05
PROJECT NO.	203719		

Acton 319 Grant Sampling Results --- Preconstruction/Outfalls
Calculation of Phosphorus Loading

	18-Jun-03				2-Sep-03			
Sample Location	Concentration (mg/l)	Flow L/sec	Flow Gal/min	**ppd**	Concentration (mg/l)	cu. Ft. sec	Flow Gal/min	**ppd**
Kelly 8	-	-	-	-	0.232	0.003	1.35	**3.75E-03**
Kelly 30	0.11	230	3,646	**4.82**	-	0.72	323.14	-
Larch 12	0.07	0.018	0.29	**2.40E-04**	0.03	0.067 (1)	1.06	**3.83E-04**
Horseshoe	0.06	186	2,948	**2.13**	-	1.03	462.26	-
Pond In 3	-	38	602	-	0.069	0.04	17.95	**1.49E-02**

(1) in liters per second

Conversion Factor Calculations

From	To						Factor
liters	gallons	gallon	60 sec			→	**15.85**
second	minute	3.785 liter	minute				
From	To						
cu. Ft.	gallons	7.48 gal	60 sec			→	**448.80**
sec	minute	cu. Ft.	minute				
From	To						
gal - mg	pounds	grams	pounds	3.785 liter	1440 min	→	**0.0120**
min - liter	day	1000 mg	453.6 grams	gallon	day		

Woodard & Curran, Inc.

35 NEW ENGLAND BUSINESS CEN
SUITE 180
ANDOVER, MASSACHUSETTS 018
978-557-8150 • 1-866-702-6371
FAX 978-557-7948

CLIENT	Town of Acton, MA		
PROJECT	s.319 Grant Project		
DESIGNED BY	RJR	DATE	06/23/05
CHECKED BY	EJF	DATE	06/23/05
PROJECT NO.	203719		

Basic Data

	Diameter	Material	Slope	N	width or diam (in)	Methods	
Inlet 1	15	inch RCP	0.05	0.015	24 width	1	V from Circular Channel Ratios (d/D gives V/Vfull)
Inlet 2	16	inch CMP	0.024	0.015	24 width	2	Area from Hydraulic Elements Table (A/D^2)
Inlet 3	6	inch PVC	N/A	N/A	6 diameter	3	Q from Mannings formula
Outlet	18	inch RCP	N/A	N/A	24 width	4	Q = A*V
					at flow measuring location		

Flow Monitoring Data - Calculate Flow Rate

		Velocity (fps)	depth (in)	d/D	V/Vfull	Vfull	V	A/D^2	A (sq ft)	Rh	**Flow Rate (cfs)**	Method	
02-Apr-05													
	Inlet 1	N/A	3						0.50	0.20	**3.80**	3	
	Inlet 2	N/A	0.25						0.04	0.02	**0.05**	3	
	Inlet 3	N/A	4.5	0.75	0.98	2.20	2.16	0.6318	0.16		**0.34**	1,2,4	
	Outlet	N/A	(overflow)						N/A				
24-Apr-05													Q=A/V
	Inlet 1	7.6	3						0.50	0.20	**3.80**	3 and 4	3.8
	Inlet 2	N/A	0.125						0.02	0.01	**0.02**	3	
	Inlet 3	1.76	3	0.5		2.2		0.3927	0.10		**0.17**	2,4	
	Outlet	7.8	2						0.33		**2.60**	4	
27-Apr-05							Adjusted V						Q=AV
	Inlet 1	3.97	1.5				3.07		0.25	0.11	**1.28**	3	0.9925
	Inlet 2	N/A	0.125						0.02	0.01	**0.02**	3	
	Inlet 3	2.5	2	0.33			1.93	0.23	0.06		**0.11**	2,4	
	Outlet	6.6	1.5				5.10		0.25		**1.28**	4	

Notes

02-Apr-05
Estimate outlet flow = inlet flow
No velocity measured.
V full from flow measurements 4/24/05

24-Apr-05 Depth of flow too shallow in Inlet 2 for velocity reading
Inlet 3 d/D = .5. From Circular Channel Ratios Vfull = 1.76/.8=2.2fps
Flow rate calculated by methods 3 and 4 match for Inlet 1 (only inlet with sufficient data for comparison) - Velocity measurements check

27-Apr-05 Flow rate calculated by methods 3 and 4 do not match - cannot confirm that velocity measurements are accurate for this round
To adjust (estimate) velocity, take ratios of Q3/Q4 using Inlet 1. Inlet now approximates Outlet flow

Woodard & Curran, Inc.

35 NEW ENGLAND BUSINESS CENTER
SUITE 180
ANDOVER, MASSACHUSETTS 01810
978-557-8150 • 1-866-702-6371
FAX 978-557-7948

CLIENT	Town of Acton, MA		
PROJECT	s.319 Grant Project		
DESIGNED BY	RJR	DATE	03/11/05
CHECKED BY	EJF	DATE	06/23/05
PROJECT NO.	203719		

Flow Measurements (in gpm)

	Kelly 8-inch pipe	Kelly 30-inch pipe	Larch 12-inch pipe	Horseshoe Outlet	Wetland In 1	Wetland In 2	Wetland In 3	Wetland In Total	Out (1)
Pre-Construction Sampling									
18-Jun-03	-	3,646	0.29	2,948	-	-	602	602	-
2-Sep-03	1.35	323	1.06	462	-	-	17.95	17.95	-
Post-Construction Sampling									
2-Apr-05					1705	21	153	1879	1879
24-Apr-05					1705	7	78	1790	1167
27-Apr-05					576	7	49	632	573
Average									

(1) Assume flow out of wetland is approximately equal to flow in - Flow shortcircuited over edges

Woodard & Curran, Inc.

35 NEW ENGLAND BUSINESS CENTER
SUITE 180
ANDOVER, MASSACHUSETTS 01810
978-557-8150 • 1-866-702-6371
FAX 978-557-7948

CLIENT	Town of Acton, MA		
PROJECT	s.319 Grant Project		
DESIGNED BY	RJR	DATE	03/11/05
CHECKED BY	EJF	DATE	06/23/05
PROJECT NO.	203719		

Phosphorus Concentrations (in mg/l)

	Kelly 8-inch pipe	Kelly 30-inch pipe	Larch 12-inch pipe	Horseshoe Outlet	Wetland In 1	Wetland In 2	Wetland In 3	Wetland In Total	Wetland Out	Removal Percent	Swimming Pond
Pre-Construction Sampling											
18-Jun-03	-	0.11	0.07	0.06	-	-	-	-	-	N/A	-
2-Sep-03	0.232	-	0.03	-	-	-	0.069	0.069	-	N.A	-
Post-Construction Sampling											
2-Apr-05				mg/l	0.0931	0.0191	BRL	0.085	0.0241	71.68%	0.058
				ppd				1.92	0.54		
24-Apr-05				mg/l	0.0147	0.0302	BRL	0.014	0.025	N/A	0.0764
				ppd				0.31	0.35		
27-Apr-05				mg/l	0.007	0.026	BRL	0.007	0.038	N/A	0.035
				ppd				0.05	0.26		
Average											

BRL = 0.005 mg/l

Woodard & Curran, Inc.

35 NEW ENGLAND BUSINESS CENTER
SUITE 180
ANDOVER, MASSACHUSETTS 01810
978-557-8150 • 1-866-702-6371
FAX 978-557-7948

CLIENT	Town of Acton, MA		
PROJECT	s.319 Grant Project		
DESIGNED BY	RJR	DATE	03/11/05
CHECKED BY	EJF	DATE	06/23/05
PROJECT NO.	203719		

Nitrogen Concentrations (in mg/l)

	Kelly 8-inch pipe	Kelly 30-inch pipe	Larch 12-inch pipe	Horseshoe Outlet	Wetland In 1	Wetland In 2	Wetland In 3	Wetland In Total	Wetland Out	Removal Percent	Swimming Pond
Pre-Construction Sampling											
18-Jun-03	-	0.11	0.07	0.06	-	-	-		-	N/A	-
2-Sep-03	0.232	-	0.03	-	-	-	0.18	0.18	-	N/A	-
Post-Construction Sampling											
2-Apr-05				mg/l	-	-	-	N/A	-	N/A	-
				ppd							
24-Apr-05				mg/l	BRL	0.27	0.24	0.107	BRL	6%	-
				ppd							
27-Apr-05				mg/l	BRL	0.21	0.26	0.114	BRL	12%	-
				ppd							
Average											

BRL = 0.1 mg/l

Woodard & Curran, Inc.

35 NEW ENGLAND BUSINESS CENTER
SUITE 180
ANDOVER, MASSACHUSETTS 01810
978-557-8150 • 1-866-702-6371
FAX 978-557-7948

CLIENT	Town of Acton, MA		
PROJECT	s.319 Grant Project		
DESIGNED BY	RJR	DATE	03/11/05
CHECKED BY	EJF	DATE	06/23/05
PROJECT NO.	203719		

Total Suspended Solids (in mg/l)

	Kelly 8-inch pipe	Kelly 30-inch pipe	Larch 12-inch pipe	Horseshoe Outlet	Wetland In 1	Wetland In 2	Wetland In 3	Wetland In Total	Wetland Out	Removal Percent	Swimming Pond
Pre-Construction Sampling											
18-Jun-03	-	0.11	0.07	0.06	-	-	-		-		-
2-Sep-03	0.232	-	0.03	-	-	-	BRL		-		-
Post-Construction Sampling											
2-Apr-05				mg/l	34	BRL	BRL	31	BRL	84%	-
				ppd							
24-Apr-05				mg/l	BRL	BRL	BRL	N/A	8	N/A	-
27-Apr-05				mg/l	BRL	BRL	BRL	N/A	BRL	N/A	-
Average											

Inlet min = 0.05 mg/l
BRL = 5 mg/l

Woodard & Curran, Inc.

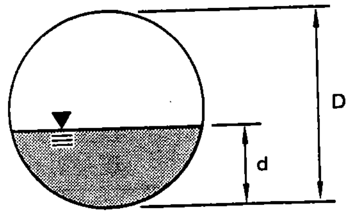
35 NEW ENGLAND BUSINESS CENTER
SUITE 180
ANDOVER, MASSACHUSETTS 01810
978-557-8150 • 1-866-702-6371
FAX 978-557-7948

CLIENT	Town of Acton, MA		
PROJECT	s.319 Grant Project		
DESIGNED BY	RJR	DATE	03/11/05
CHECKED BY	EJF	DATE	06/23/05
PROJECT NO.	203719		

Survey Data and Calculations

Inlet 1	rod out	rod in			elev delta	length	slope
	8.07	5.57			2.5	50	0.05
Inlet 2	BS	FS	elev	HI			
			100				
	10.06			110.06			
TP1		2.64	107.42				
	8.61			116.03			
TP2		1.7	114.33				
Depth	5.2		109.13				
					9.13	387.3	0.024

Appendix E: Area, Wetted Perimeter and Hydraulic Radius of Partially Filled Circular Pipes

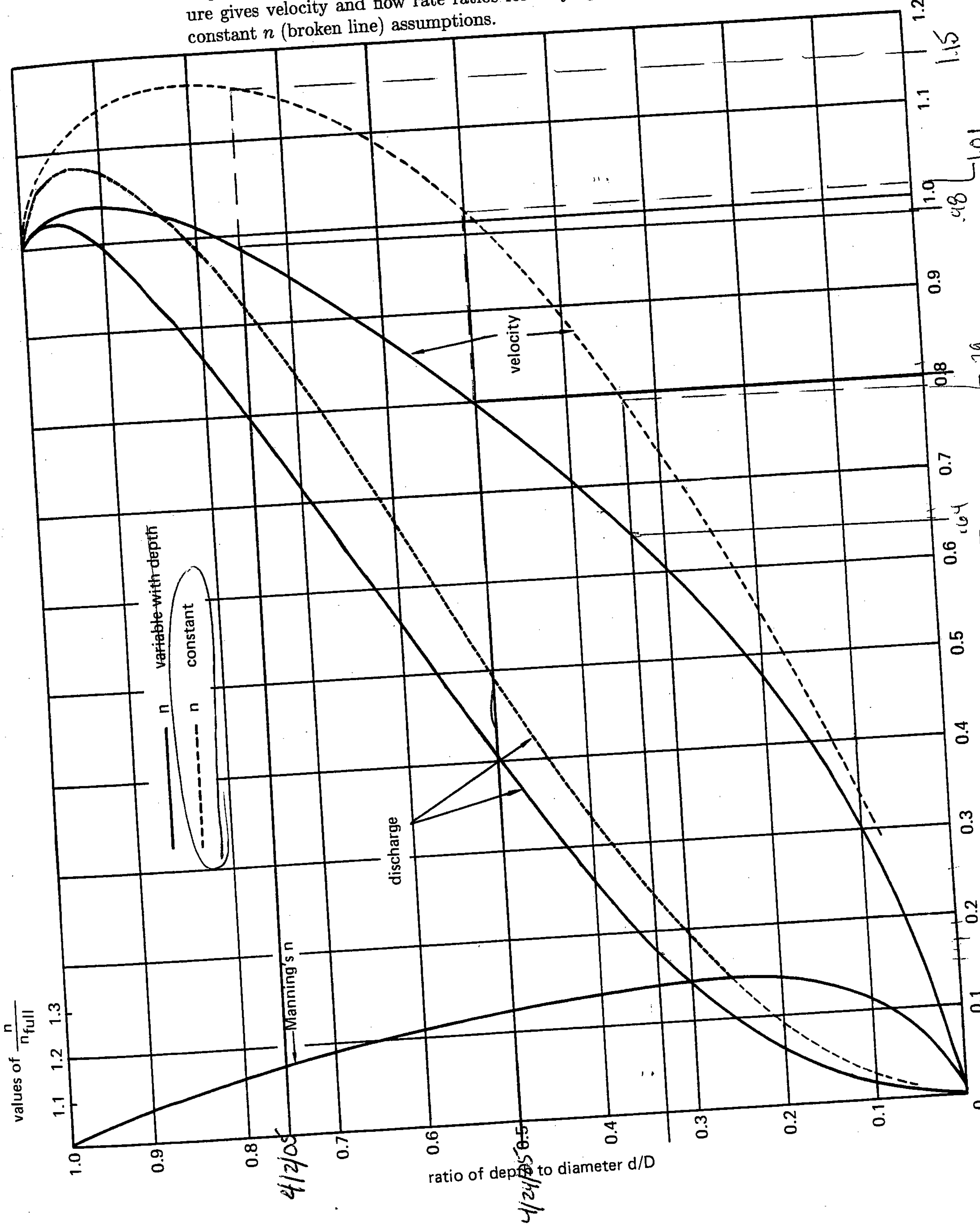


d/D	area/D²	wet. per./D	hyd. rad./D	d/D	area/D²	wet. per./D	hyd. rad./D
0.01	0.0013	0.2003	0.0066	0.51	0.4027	1.5908	0.2531
0.02	0.0037	0.2838	0.0132	0.52	0.4127	1.6108	0.2561
0.03	0.0069	0.3482	0.0197	0.53	0.4227	1.6308	0.2591
0.04	0.0105	0.4027	0.0262	0.54	0.4327	1.6509	0.2620
0.05	0.0147	0.4510	0.0326	0.55	0.4426	1.6710	0.2649
0.06	0.0192	0.4949	0.0389	0.56	0.4526	1.6911	0.2676
0.07	0.0242	0.5355	0.0451	0.57	0.4625	1.7113	0.2703
0.08	0.0294	0.5735	0.0513	0.58	0.4723	1.7315	0.2728
0.09	0.0350	0.6094	0.0574	0.59	0.4822	1.7518	0.2753
0.10	0.0409	0.6435	0.0635	0.60	0.4920	1.7722	0.2776
0.11	0.0470	0.6761	0.0695	0.61	0.5018	1.7926	0.2797
0.12	0.0534	0.7075	0.0754	0.62	0.5115	1.8132	0.2818
0.13	0.0600	0.7377	0.0813	0.63	0.5212	1.8338	0.2839
0.14	0.0688	0.7670	0.0871	0.64	0.5308	1.8546	0.2860
0.15	0.0739	0.7954	0.0929	0.65	0.5404	1.8755	0.2881
0.16	0.0811	0.8230	0.0986	0.66	0.5499	1.8965	0.2899
0.17	0.0885	0.8500	0.1042	0.67	0.5594	1.9177	0.2917
0.18	0.0961	0.8763	0.1097	0.68	0.5687	1.9391	0.2935
0.19	0.1039	0.9020	0.1152	0.69	0.5780	1.9606	0.2950
0.20	0.1118	0.9273	0.1206	0.70	0.5872	1.9823	0.2962
0.21	0.1199	0.9521	0.1259	0.71	0.5964	2.0042	0.2973
0.22	0.1281	0.9764	0.1312	0.72	0.6054	2.0264	0.2984
0.23	0.1365	1.0003	0.1364	0.73	0.6143	2.0488	0.2995
0.24	0.1449	1.0239	0.1416	0.74	0.6231	2.0714	0.3006
0.25	0.1535	1.0472	0.1466	→ 0.75	0.6318	2.0944	0.3017
0.26	0.1623	1.0701	0.1516	0.76	0.6404	2.1176	0.3025
0.27	0.1711	1.0928	0.1566	0.77	0.6489	2.1412	0.3032
0.28	0.1800	1.1152	0.1614	0.78	0.6573	2.1652	0.3037
0.29	0.1890	1.1373	0.1662	0.79	0.6655	2.1895	0.3040
0.30	0.1982	1.1593	0.1709	0.80	0.6736	2.2143	0.3042
0.31	0.2074	1.1810	0.1755	0.81	0.6815	2.2395	0.3044
0.32	0.2167	1.2025	0.1801	0.82	0.6893	2.2653	0.3043
→ 0.33	0.2260	1.2239	0.1848	0.83	0.6969	2.2916	0.3041
0.34	0.2355	1.2451	0.1891	0.84	0.7043	2.3186	0.3038
0.35	0.2450	1.2661	0.1935	0.85	0.7115	2.3462	0.3033
0.36	0.2546	1.2870	0.1978	0.86	0.7186	2.3746	0.3026
0.37	0.2642	1.3078	0.2020	0.87	0.7254	2.4038	0.3017
0.38	0.2739	1.3284	0.2061	0.88	0.7320	2.4341	0.3008
0.39	0.2836	1.3490	0.2102	0.89	0.7384	2.4655	0.2996
0.40	0.2934	1.3694	0.2142	0.90	0.7445	2.4981	0.2980
0.41	0.3032	1.3898	0.2181	0.91	0.7504	2.5322	0.2963
0.42	0.3130	1.4101	0.2220	0.92	0.7560	2.5681	0.2944
0.43	0.3229	1.4303	0.2257	0.93	0.7612	2.6061	0.2922
0.44	0.3328	1.4505	0.2294	0.94	0.7662	2.6467	0.2896
0.45	0.3428	1.4706	0.2331	0.95	0.7707	2.6906	0.2864
0.46	0.3527	1.4907	0.2366	0.96	0.7749	2.7389	0.2830
0.47	0.3627	1.5108	0.2400	0.97	0.7785	2.7934	0.2787
0.48	0.3727	1.5308	0.2434	0.98	0.7816	2.8578	0.2735
0.49	0.3827	1.5508	0.2467	0.99	0.7841	2.9412	0.2665
→ 0.50	0.3927	1.5708	0.2500	1.00	0.7854	3.1416	0.2500

From Civil Engineering Reference Manual, 5th Edition, Michael R. Lindeburg, P.E.

Appendix C: Circular Channel Ratios

Experiments have shown that n varies slightly with depth. This figure gives velocity and flow rate ratios for varying n (solid line) and constant n (broken line) assumptions.



$$C = \frac{uR_h^{1/6}}{n} \tag{10.4}$$

$$q = \left(\frac{u}{n}\right) y \, R^{2/3} S_o^{1/2}$$

Manning's Eq

$$Q = \left(\frac{u}{n}\right) A R_h^{2/3} S_o^{1/2} \tag{10.5}$$

where $u = 1$ for SI units and $u = 1.49$ for FSS units.

The Manning n is obtained from a descriptive statement of the channel character; some typical values are given in Table 6. There is no substitute for experience and judgment in the interpretation and selection of values for n. Systematic experiments and analyses, similar to those of Nikuradse and Colebrook in the field of pipe flow, have yet to produce a clear definition of open-channel roughness or a scientific interpretation of the Chezy C or Manning n.

$$R_h = \frac{\text{Area}}{\text{Wetted Perimeter}}$$

Table 6 Typical Values of n[9]

Partly-full pipes	0.024
Corrugated metal drains	0.013
Concrete culverts (normal)	0.013
Drainage tiles (clay)	0.013
Sewers (normal)	
Man-made channels (lined)	0.012
Steel	0.012
Timber	0.013
Concrete (troweled)	0.019–0.022
Concrete (gunite)	0.015
Good ashlar masonry or brickwork	0.025
Rubble masonry	0.013–0.016
Asphalt	0.022
Earth (clean)	0.027–0.035
Earth (with vegetation)	
Natural channels	0.030
Clean and straight	0.040
Winding with some pools and shoals	0.100
Very weedy, deep pools	0.040–0.050
Mountain streams	
Major streams (width greater than 100 ft or 30 m at flood stage)	0.025–0.100

[9] Table 6 was adapted, with permission of McGraw-Hill Book Company, from V. T. Chow, *Open Channel Hydraulics*, Chapter 5, copyright © 1959 McGraw-Hill Book Co. H. H. Barnes, "Roughness Characteristics of Natural Channels," *U.S. Geol. Survey Wat. Supply Pap.* 1849, 1967, gives a set of typical n values together with matching descriptive data and color photographs of natural channels.

3 sampling dates circled Lisa Lyons CDW

UNEDITED LOCAL CLIMATOLOGICAL DATA

NOAA, National Climatic Data Center

Month: 04/2005

Station Location: LAURENCE G HANSCOM FIELD AIRPORT (BED)
BEDFORD , MA

Lat. 42°28'N Lon. 71°17'W

Elevation(Ground): 166 ft. above sea level

Date	Temperature (Fahrenheit) Max	Min	Avg	Dep From Normal	Avg. Dew pt.	Avg Wet Bulb	Degree Days Base 65 Degrees Heating	Cooling	Significant Weather	Snow/Ice on Ground(In) 0600 LST Depth	1200 LST Water Equiv	Precipitation (In) 2400 LST Snow Fall	2400 LST Water Equiv	Pressure(inches of Hg) Avg. Station	Avg. Sea level	Wind: Speed=mph Dir=tens of degrees Resultant Speed	Res Dir	Avg. Speed	max 5-sec Speed	Dir	max 2-min Speed	Dir	Date
1	57	38	48	M	35	40	17	0	-	M	-	M	0.01	29.88	30.14	2.2	12	5.5	16	10	15	10	1
2	50	37	44	M	41	42	21	0	RA FG+ FG	M	-	M	0.90	29.62	29.88	11.7	9	11.8	26	10	23	10	2
3	55	41	48	M	39	44	17	0	RA FG	M	-	M	0.54	29.18	32.40	12.2	16	13.3	36	11	26	10	3
4	53	35	44	M	34	39	21	0	-	M	-	M	T	29.39	30.39	7.9	27	8.7	23	30	18	30	4
5	64	31	48	M	24	39	17	0	-	M	-	M	0.00	29.77	30.04	6.7	30	7.9	26	34	22	32	5
6	66	35	51	M	32	43	14	0	-	M	-	M	T	29.89	30.16	2.4	12	3.4	20	16	14	16	6
7	69	42	56	M	44	50	9	0	RA FG	M	-	M	0.09	29.63	29.89	1.8	17	5.9	28	21	22	22	7
8	62	39	51	M	36	44	14	0	RA FG	M	-	M	0.17	29.68	29.95	2.4	33	6.5	22	34	18	34	8
9	60	34	47	M	29	39	18	0	-	M	-	M	0.00	29.91	30.16	2.6	11	5.1	17	13	14	11	9
10	72	30	51	M	25	41	14	0	FG	M	-	M	0.00	29.78	30.05	5.3	1	6.7	24	5	20	4	10
11	53	34	44	M	16	33	21	0	-	M	-	M	0.00	29.90	30.16	6.3	3	9.5	23	36	17	8	11
12	52	28	40	M	22	32	25	0	SN FG	M	-	M	0.03	29.76	30.02	5.3	34	9.5	30	32	24	10	12
13	52	27	40*	M	24	34	25	0	FG FZFG	M	-	M	0.00	29.71	29.98	3.4	32	5.1	20	36	16	36	13
14	58	31	45	M	28	37	20	0	-	M	-	M	0.00	29.89	30.16	5.3	8	7.8	25	14	20	10	14
15	54	27	41	M	16	32	24	0	-	M	-	M	0.00	30.27	30.53	4.8	8	6.7	29	4	22	9	15
16	60	24	42	M	18	34	23	0	-	M	-	M	0.00	30.28	30.55	3.3	13	4.6	17	10	15	10	16
17	76	29	53	M	25	42	12	0	-	M	-	M	0.00	29.88	30.15	1.2	29	3.5	18	30	15	30	17
18	71	39	55	M	24	43	10	0	-	M	-	M	0.00	29.82	30.08	3.9	35	5.0	24	1	18	36	18
19	78	34	56	M	29	46	9	0	-	M	-	M	0.00	29.71	30.00	3.4	24	4.9	18	24	16	25	19
20	87*	50	69*	M	44	55	0	4	RA FG	M	-	M	0.12	29.48	29.73	7.4	25	10.8	31	5	26	5	20
21	58	36	47	M	28	40	18	0	RA FG	M	-	M	0.15	29.68	29.93	8.0	36	9.8	24	1	20	1	21
22	63	28	46	M	26	38	19	0	HZ	M	-	M	0.05	29.75	30.01	5.4	18	6.9	28	19	21	19	22
23	59	43	51	M	48	49	14	0	RA FG	M	-	M	0.45	29.45	29.72	5.6	9	8.3	21	16	16	14	23
24	63	38	51	M	46	50	14	0	RA FG	M	-	M	0.59	29.21	32.30	10.8	16	12.2	29	15	21	18	24
25	52	34	43	M	33	40	22	0	RA FG	M	-	M	0.15	29.31	31.28	8.9	23	9.6	30	22	24	23	25
26	70	35	53	M	35	45	12	0	-	M	-	M	0.00	29.71	29.98	8.6	21	10.0	31	20	24	21	26
27	54	50	52	M	49	50	13	0	RA FG	M	-	M	0.37	29.60	29.86	7.6	11	9.0	24	11	18	9	27
28	60	43	52	M	41	46	13	0	FG	M	-	M	0.06	29.51	29.75	7.8	31	9.9	29	31	22	30	28
29	63	39	51	M	32	43	14	0	-	M	-	M	T	29.71	29.96	9.9	24	11.1	29	26	24	27	29
30	57	48	53	M	47	50	12	0	RA FG HZ	M	-	M	0.45	29.67	29.93	3.4	15	6.3	18	20	14	19	30
	61.6	36.0	48.8	------	32.3	42.0	16.1	.1	<Monthly Averages	Totals>			4.13	29.70	30.24	0.7	17.9	7.9	<Monthly Average				
			.0	------					<----------Departure From Normal---------->				0.00										

Degree Days — Monthly Total, Departure — Season to Date Total, Departure

Degree Days	Monthly Total	Monthly Departure	Season to Date Total	Season to Date Departure
Heating:	482	-255	6261	-523
Cooling:	4	-255	4	-2892

Greatest 24-hr Precipitation: 1.40 Date: 2-3

Greatest 24-hr Snowfall: Date:

Greatest Snow Depth: 0 Date:

Sea Level Pressure		Date	Time
Maximum	30.68	16	0805
Minimum	29.40	25	0220

Number of Days with ------->

Max Temp >=90: 0
Max Temp <=32: 0
Thunderstorms : 0

Min Temp <=32: 9
Min Temp <=0 : 0
Heavy Fog : 1

Precipitation >=.01 inch: 15
Precipitation >=.10 inch: 10
Snowfall >=1.0 inch : 0

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.

203719

SPECTRUM ANALYTICAL, INC.

Laboratory Report

Location Acton Stormwater - Acton, MA
Client: CDW

Client Project No: 88900
Submittal 6/19/2003

Lab ID AD94131 **Client Id:** KELLY 30 **Collection Date:** 6/18/2003 **Matrix:** Storm Water

Parameter	Results	Units	PQL	Start Date	Time	Analyst	Method
General Chemistry							
Nitrate Nitrogen	1.53	mg/L	0.05	6/20/2003	10:00	JAK	SM4500-NO3-E
Total Phosphorus	0.11	mg/L	0.01	6/23/2003		YV	EPA 365.2
Total Suspended Solids	10	mg/L	5.0	6/20/2003		ALJ	SM 2540D/160.2

NOTE: Sample analyzed for nitrite prior to preservation with sulfuric acid within 48 hours of collection extending the holding time for nitrate to 28 days.

Lab ID AD94132 **Client Id:** HSHOE DR **Collection Date:** 6/18/2003 **Matrix:** Storm Water

Parameter	Results	Units	PQL	Start Date	Time	Analyst	Method
General Chemistry							
Nitrate Nitrogen	2.2	mg/L	0.05	6/20/2003	10:00	JAK	SM4500-NO3-E
Total Phosphorus	0.06	mg/L	0.01	6/23/2003		YV	EPA 365.2
Total Suspended Solids	7.0	mg/L	5.0	6/20/2003		ALJ	SM 2540D/160.2

NOTE: Sample analyzed for nitrite prior to preservation with sulfuric acid within 48 hours of collection extending the holding time for nitrate to 28 days.

Lab ID AD94133 **Client Id:** LARCH 12 **Collection Date:** 6/18/2003 **Matrix:** Storm Water

Parameter	Results	Units	PQL	Start Date	Time	Analyst	Method
General Chemistry							
Nitrate Nitrogen	1.67	mg/L	0.05	6/20/2003	10:00	JAK	SM4500-NO3-E
Total Phosphorus	0.07	mg/L	0.01	6/23/2003		YV	EPA 365.2
Total Suspended Solids	Below det lim	mg/L	5.0	6/20/2003		ALJ	SM 2540D/160.2

NOTE: Sample analyzed for nitrite prior to preservation with sulfuric acid within 48 hours of collection extending the holding time for nitrate to 28 days.

Lab ID AD94134 **Client Id:** POND IN3 **Collection Date:** 6/18/2003 **Matrix:** Storm Water

Parameter	Results	Units	PQL	Start Date	Time	Analyst	Method
General Chemistry							
Nitrate Nitrogen	2.43	mg/L	0.01	6/20/2003	10:00	JAK	SM4500-NO3-E
Total Phosphorus	Below det lim	mg/L	0.01	6/23/2003		YV	EPA 365.2
Total Suspended Solids	Below det lim	mg/L	5.0	6/20/2003		ALJ	SM 2540D/160.2

NOTE: Sample analyzed for nitrite prior to preservation with sulfuric acid within 48 hours of collection extending the holding time for nitrate to 28 days.

Lab ID AD94135 **Client Id:** DUP **Collection Date:** 6/18/2003 **Matrix:** Storm Water

Parameter	Results	Units	PQL	Start Date	Time	Analyst	Method
General Chemistry							
Nitrate Nitrogen	2.13	mg/L	0.05	6/20/2003	10:00	JAK	SM4500-NO3-E
Total Phosphorus	0.06	mg/L	0.01	6/23/2003		YV	EPA 365.2
Total Suspended Solids	6.0	mg/L	5.0	6/20/2003		ALJ	SM 2540D/160.2

NOTE: Sample analyzed for nitrite prior to preservation with sulfuric acid within 48 hours of collection extending the holding time for nitrate to 28 days.

Reviewed

Validated by:

Quality Service/Quality Assurance

President/Laboratory Director

6/25/2003

Lisa Lyons
7/24/03

889.00/ Acton Stormwater Flow Calculations

June 18 Sampling Round

Kelly's Corner

3" deep flow in 30"-dia. pipe

Instantaneous Flow = 38.8 m/sec

Using ~~Attached~~ Table:

$\frac{d}{D} = \frac{3''}{30''} = 0.1$, so $\frac{Area}{D^2} = 0.0409$

Area $= (0.0409)(\cancel{15}\ 30\ in)^2 = \cancel{9.203}\ 36.81\ in^2$

$Q = VA = (38.8\ \frac{m}{sec})(\cancel{9.203}\ 36.81\ in^2)(645.16 \times 10^{-6}\ \frac{m^2}{in^2})$

$Q = \boxed{\cancel{0.23}\ 0.92\ \frac{m^3}{sec}}$

Larch Rd.

12" dia. pipe. Couldn't measure flow with flow meter directly due to flow angle (steep flow angle). Too little flow in pipe to hold flow meter in pipe. Measured flow directly as:

$\frac{5.2\ L}{285\ sec} = \boxed{0.018\ \frac{L}{sec}}$

889.00 / Acton Stormwater Flow Calculations

Horseshoe Drive

2" deep flow in weir 30" across

Instantaneous Flow = 4.8 m/sec

Flow Area = (2")(30") = 60 in²

$Q = VA = (4.8\ m/sec)(60\ in^2)(645.16 \times 10^{-6}\ \frac{m^2}{in^2})$

$Q = \boxed{0.186\ \frac{m^3}{sec}}$

Recirculation Pond

No flow in two large inlets.

1.5" deep flow in 6" dia pipe.

Instantaneous flow = 10.6 m/sec

Using Attached table:

$\frac{d}{D} = \frac{1.5''}{6''} = 0.25$, so $\frac{Area}{D^2} = 0.1535$

$Area = (0.1535)(6\ in)^2 = 5.526\ in^2$

$Q = VA = (10.6\ \frac{m}{sec})(5.526\ in^2)(645.16 \times 10^{-6}\ \frac{m^2}{in^2})$

$= \boxed{0.038\ \frac{m^3}{sec}}$

No flow at Quaboag Rd., Wetherbee Street, or 8" dia. pipe at Kelly's Corner.

Report Date:
11-Sep-03 12:26

- [x] Final Report
- [ ] Re-Issued Report
- [ ] Revised Report

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

Laboratory Report

CDW Consultants, Inc.
40 Speen Street; Suite 301
Framingham, MA 01701
Attn: Lisa Lyons

Project:Acton Stormwater - MA
Project #:889.00

Laboratory ID	Client Sample ID	Matrix	Date Sampled	Date Received
SA01704-01	Kelly-30	Surface Water	02-Sep-03 10:30	02-Sep-03 15:55
SA01704-02	Kelly-8	Surface Water	02-Sep-03 10:40	02-Sep-03 15:55
SA01704-03	Larch-12	Surface Water	02-Sep-03 11:20	02-Sep-03 15:55
SA01704-04	HShoe-Dr	Surface Water	02-Sep-03 12:00	02-Sep-03 15:55
SA01704-05	Dup	Surface Water	02-Sep-03 11:20	02-Sep-03 15:55
SA01704-06	Pond-In3	Surface Water	02-Sep-03 13:15	02-Sep-03 15:55

I attest that all information contained within this report has been reviewed for accuracy and checked against all quality control requirements outlined in each applicable method and meet the requirements of NELAC.
This report may not be reproduced, except in full, without written approval from Spectrum Analytical, Inc.

Massachusetts Certification # M-MA138
Connecticut # PH-0777
Florida # E87600
Maine # MA138
New Hampshire # 2538
New York # 11393
Rhode Island # 98
USDA # S-51435

ACCREDITED IN ACCORDANCE WITH nelac

Authorized by:

Hanibal C. Tayeh, Ph.D.
President/Laboratory Director

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Kelly-30 SA01704-01	889.00	Surface Water	02-Sep-03 10:30	02-Sep-03

Analyte(s)	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters									
Nitrate as N	0.990	0.100 mg/l	1	EPA 300.0	03-Sep-03 11:00	03-Sep-03	3090148	Chri	
Phosphorus as P	BRL	0.020 mg/l	1	10-115-01-1-D	10-Sep-03	10-Sep-03	3090495	jak	
Total Suspended Solids	13.0	5.00 mg/l	1	SM2540D	06-Sep-03	08-Sep-03	3090338	RB	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Kelly-8 SA01704-02	889.00	Surface Water	02-Sep-03 10:40	02-Sep-03

Analyte(s)	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters									
Nitrate as N	1.06	0.100 mg/l	1	EPA 300.0	03-Sep-03 11:00	03-Sep-03	3090148	Chri	
Phosphorus as P	0.232	0.020 mg/l	1	10-115-01-1-D	10-Sep-03	10-Sep-03	3090495	jak	
Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	06-Sep-03	08-Sep-03	3090338	RB	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Larch-12 SA01704-03	889.00	Surface Water	02-Sep-03 11:20	02-Sep-03

Analyte(s)	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters									
Nitrate as N	0.190	0.100 mg/l	1	EPA 300.0	03-Sep-03 11:00	03-Sep-03	3090148	Chri	
Phosphorus as P	0.030	0.020 mg/l	1	10-115-01-1-D	10-Sep-03	10-Sep-03	3090495	jak	
Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	06-Sep-03	08-Sep-03	3090338	RB	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
HShoe-Dr	889.00	Surface Water	02-Sep-03 12:00	02-Sep-03
SA01704-04				

Analyte(s)	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters									
Nitrate as N	1.89	0.100 mg/l	1	EPA 300.0	03-Sep-03 11:00	03-Sep-03	3090148	Chri	
Phosphorus as P	BRL	0.020 mg/l	1	10-115-01-1-D	10-Sep-03	10-Sep-03	3090495	jak	
Total Suspended Solids	12.0	5.00 mg/l	1	SM2540D	06-Sep-03	08-Sep-03	3090338	RB	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Dup SA01704-05	889.00	Surface Water	02-Sep-03 11:20	02-Sep-03

Analyte(s)	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters									
Nitrate as N	0.190	0.100 mg/l	1	EPA 300.0	03-Sep-03 11:00	03-Sep-03	3090148	Chri	
Phosphorus as P	0.057	0.020 mg/l	1	10-115-01-1-D	10-Sep-03	10-Sep-03	3090495	jak	
Total Suspended Solids	6.00	5.00 mg/l	1	SM2540D	06-Sep-03	08-Sep-03	3090338	RB	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Pond-In3 SA01704-06	889.00	Surface Water	02-Sep-03 13:15	02-Sep-03

Analyte(s)	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters									
Nitrate as N	0.180	0.100 mg/l	1	EPA 300.0	03-Sep-03 11:00	03-Sep-03	3090148	Chri	
Phosphorus as P	0.069	0.020 mg/l	1	10-115-01-1-D	10-Sep-03	10-Sep-03	3090495	jak	
Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	06-Sep-03	08-Sep-03	3090338	RB	

Analyte(s)	Result	*RDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch 3090148 - General Preparation										
Blank (3090148-BLK1)				Prepared & Analyzed: 03-Sep-03						
Nitrate as N	BRL	0.100	mg/l							
LCS (3090148-BS1)				Prepared & Analyzed: 03-Sep-03						
Nitrate as N	1.91	0.100	mg/l	2.00		95.5	90-110			
LCS (3090148-BS2)				Prepared & Analyzed: 03-Sep-03						
Nitrate as N	0.390	0.100	mg/l	0.400		97.5	90-110			
Reference (3090148-SRM1)				Prepared & Analyzed: 03-Sep-03						
Nitrate as N	2.40	0.100	mg/l	2.50		96.0	90-110			
Reference (3090148-SRM2)				Prepared & Analyzed: 03-Sep-03						
Nitrate as N	0.500	0.100	mg/l	0.500		100	90-110			
Batch 3090338 - General Preparation										
Blank (3090338-BLK1)				Prepared: 06-Sep-03 Analyzed: 08-Sep-03						
Total Suspended Solids	BRL	5.00	mg/l							
Duplicate (3090338-DUP1)	**Source: SA01737-13**			Prepared: 06-Sep-03 Analyzed: 08-Sep-03						
Total Suspended Solids	BRL	5.00	mg/l		BRL				20	
Duplicate (3090338-DUP2)	**Source: SA01810-01**			Prepared: 06-Sep-03 Analyzed: 08-Sep-03						
Total Suspended Solids	98.0	5.00	mg/l		78.0			22.7	20	QR-03
Duplicate (3090338-DUP3)	**Source: SA01810-19**			Prepared: 06-Sep-03 Analyzed: 08-Sep-03						
Total Suspended Solids	BRL	5.00	mg/l		BRL				20	
Reference (3090338-SRM1)				Prepared: 06-Sep-03 Analyzed: 08-Sep-03						
Total Suspended Solids	92.0	10.0	mg/l	87.4		105	80-120			
Batch 3090495 - General Preparation										
Blank (3090495-BLK1)				Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	BRL	0.020	mg/l							
Blank (3090495-BLK2)				Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	BRL	0.020	mg/l							
LCS (3090495-BS1)				Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	0.566	0.020	mg/l	0.600		94.3	85-115			
LCS (3090495-BS2)				Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	0.797	0.020	mg/l	0.800		99.6	85-115			
Duplicate (3090495-DUP1)	**Source: SA01579-02**			Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	BRL	0.020	mg/l		BRL				20	
Duplicate (3090495-DUP2)	**Source: SA01580-01**			Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	BRL	0.020	mg/l		BRL				20	
Duplicate (3090495-DUP3)	**Source: SA01736-01**			Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	BRL	0.020	mg/l		BRL				20	
Matrix Spike (3090495-MS1)	**Source: SA01579-02**			Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	0.153	0.020	mg/l	0.150	BRL	102	80-120			
Matrix Spike (3090495-MS2)	**Source: SA01580-01**			Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	0.109	0.020	mg/l	0.100	BRL	109	80-120			
Matrix Spike (3090495-MS3)	**Source: SA01736-01**			Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	0.220	0.020	mg/l	0.200	BRL	110	80-120			
Reference (3090495-SRM1)				Prepared & Analyzed: 10-Sep-03						
Phosphorus as P	1.22	0.020	mg/l	1.20		102	80-120			

Notes and Definitions

QR-03	The RPD value for the sample duplicate or MS/MSD was outside the QC acceptance limits due to matrix interference. QC batch accepted based on LCS and/or LCSD recovery and/or RPD values.
BRL	Below Reporting Limit - Analyte NOT DETECTED at or above the reporting limit
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

Laboratory Control Sample (LCS): A known matrix spiked with compound(s) representative of the target analytes, which is used to document laboratory performance.

Matrix Duplicate: An intra-laboratory split sample which is used to document the precision of a method in a given sample matrix.

Matrix Spike: An aliquot of a sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Method Blank: An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

Method Detection Limit (MDL): The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

Reportable Detection Limit (RDL): The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The RDL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes the RDL analyte concentration is selected as the lowest non-zero standard in the calibration curve. Sample RDLs are highly matrix-dependent.

Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. These compounds are spiked into all blanks, standards, and samples prior to analysis. Percent recoveries are calculated for each surrogate.

SA01704 (R)

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

CHAIN OF CUSTODY RECORD

Page 1 of 1

Special Handling:
- ☒ Standard TAT - 7 to 10 business days
- ☐ Rush TAT - Date Needed: ________
- All TATs subject to laboratory approval.
- Min. 24-hour notification needed for rushes.
- All samples are disposed of after 60 days unless otherwise instructed.

Report To: CDW Consultants, Inc, 40 Speen St, Suite 301, Framingham, MA 01701

Project Mgr.: Lisa Lyons

Invoice To: Same

INV# 2309 0327

P.O. No.: ________ RQN: ________

Project No.: 889.00

Site Name: Acton Stormwater

Location: Acton State: MA

Sampler(s): L. Lyons, B. Miller

1=$Na_2S_2O_3$ 2=HCl 3=H_2SO_4 4=HNO_3 5=NaOH 6=Ascorbic Acid
7=CH_3OH 8= $NaHSO_4$ 9= 4°C 10=________

DW=Drinking Water GW=Groundwater WW=Wastewater
O=Oil SW= Surface Water SO=Soil SL=Sludge A=Air
X1=________ X2=________ X3=________

G=Grab C=Composite

Lab Id:	Sample Id:	Date:	Time:	Type	Matrix	Preservative	# of VOA Vials	# of Amber Glass	# of Clear Glass	# of Plastic	Total Suspended Solids	Total Phosphorus	Nitrate Nitrogen					Notes:
01704-01	KELLY_30	9/2/03	10:30AM	G	SW	3,9				3	X	X	X					
-02	KELLY_8	↓	10:40AM	↓	↓	↓				3	X	X	X					
-03	LARCH_12	↓	11:20AM	↓	↓	↓				3	X	X	X					
-04	HSHOE_DR	↓	12:00PM	↓	↓	↓				3	X	X	X					
-05	DUP	↓	11:20AM	↓	↓	↓				3	X	X	X					
-06	POND_IN3	↓	1:15PM	↓	↓	↓				3	X	X	X					

Relinquished by:	Received by:	Date:	Time:
Lisa Lyons	Bergeron	9/2/03	1:32 PM
Bergeron	Mtr	9/2/03	1555

☐ Fax results when available to (____)

☒ E-mail results when available to llyons@cdwconsultants.com

Condition upon Receipt: ☑ Iced ☐ Ambient ☐ 13 °C

Cooler

889.00 Acton Stormwater
Flow Calculations for
September 2 Sampling Round

Lisa Lyons
9/18/03
p. 1 of 2

CHECKED R. Rafferty
5/13/05

Kelly's Corner

30" pipe, Flow Depth = 1.5" deep = d

Instantaneous flow = 7.83 $\frac{\text{feet}}{\text{sec}}$

Using attached table:

$\frac{d}{D} = \frac{1.5''}{30''} = 0.05$, so $\frac{\text{Area}}{D^2} = 0.0147$

Area = $(0.0147)(30 \text{ in})^2 = 13.23 \text{ in}^2$

$Q = vA = 7.83 \frac{\text{feet}}{\text{sec}} \left(\frac{1 \text{ ft}}{12 \text{ in}}\right)^2 13.23 \text{ in}^2$

$Q_{30} = \boxed{0.72 \frac{\text{ft}^3}{\text{sec}}}$

8" pipe, Flow Depth = 0.5 inch

Flow Depth too shallow to use flow meter, so measured Q directly.

$Q_8 = \frac{0.5 \text{ L}}{180 \text{ sec}} \approx \boxed{0.003 \frac{\text{L}}{\text{sec}}}$

Larch Road

12" pipe, Flow Depth = 0.25"

Flow Depth too shallow for use of flow meter. Measured Q directly.

$Q = \frac{10.4 \text{ L}}{155 \text{ sec}} = \boxed{0.067 \frac{\text{L}}{\text{sec}}}$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

Lisa Lyons
9/18/03
p. 2 of 2

Horseshoe Drive

30" weir, 1 1/2" = Flow Depth

Instantaneous Flow = 3.28 $\frac{feet}{sec}$

Flow Area = (1.5")(30") = 45 in^2

$$Q = VA = 3.28 \frac{feet}{sec} \left(\frac{1\ ft}{12\ in.}\right)^2 45\ in^2$$

$$Q \simeq \boxed{1.03 \frac{ft^3}{sec}}$$

Recirculation Pond

Flow only observed in 6"-dia. pipe.

Flow Depth = 2" = d

Instantaneous Velocity = 0.73 $\frac{feet}{sec}$

Using attached table:

$$\frac{d}{D} = \frac{2"}{3"} = 0.33, \quad \frac{Area}{D^2} = 0.2260$$

$$Area = (0.2260)(6\ in)^2 = 8.136\ in^2$$

$$Q = vA = 0.73 \frac{feet}{sec} \left(\frac{1\ ft}{12\ in}\right)^2 8.136\ in^2$$

$$Q = \boxed{0.04 \frac{ft^3}{sec}}$$

Report Date:
13-Apr-05 14:11

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

☑ Final Report
☐ Re-Issued Report
☐ Revised Report

Laboratory Report

CDW Consultants, Inc.
40 Speen Street; Suite 301
Framingham, MA 01701
Attn: Lisa Lyons

Project: Acton Wetland - Acton, MA
Project #: 889.00

Laboratory ID	Client Sample ID	Matrix	Date Sampled	Date Received
SA25987-01	IN-1	Surface Water	02-Apr-05 12:05	04-Apr-05 15:25
SA25987-02	IN-3	Surface Water	02-Apr-05 12:15	04-Apr-05 15:25
SA25987-03	IN-2	Surface Water	02-Apr-05 12:30	04-Apr-05 15:25
SA25987-04	Pond	Surface Water	02-Apr-05 12:45	04-Apr-05 15:25
SA25987-05	Out	Surface Water	02-Apr-05 13:00	04-Apr-05 15:25
SA25987-06	Dup	Surface Water	02-Apr-05 00:00	04-Apr-05 15:25

I attest that the information contained within the report has been reviewed for accuracy and checked against the quality control requirements for each method. All applicable NELAC requirements have been met.
Please note that this report contains 5 pages of analytical data plus Chain of Custody document(s).

Massachusetts Certification # M-MA138/MA1110
Connecticut # PH-0777
Florida # E87600/E87936
Maine # MA138
New Hampshire # 2538/2972
New York # 11393/11840
Rhode Island # 98
USDA # S-51435
Vermont # VT-11393

ACCREDITED IN ACCORDANCE WITH nelac

Authorized by:

Hanibal C. Tayeh, Ph.D.
President/Laboratory Director

Spectrum Analytical, Inc. is a NELAC accredited laboratory organization and meets NELAC testing standards. Use of the NELAC logo however does not insure that Spectrum is currently accredited for the specific method indicated. Please refer to our "Quality" webpage at www.spectrum-analytical.com for a full listing of our current certifications.

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-1 SA25987-01	889.00	Surface Water	02-Apr-05 12:05	04-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0931	0.00500 mg/l	1	ASTM D515-88(A)	05-Apr-05	05-Apr-05	5040181	AJ	
	Total Suspended Solids	34.0	5.00 mg/l	1	SM2540D	06-Apr-05	07-Apr-05	5040342	"	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-3 SA25987-02	889.00	Surface Water	02-Apr-05 12:15	04-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	BRL	0.00500 mg/l	1	ASTM D515-88(A)	05-Apr-05	05-Apr-05	5040181	AJ	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	06-Apr-05	07-Apr-05	5040342	"	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-2 SA25987-03	889.00	Surface Water	02-Apr-05 12:30	04-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0191	0.00500 mg/l	1	ASTM D515-88(A)	05-Apr-05	05-Apr-05	5040181	AJ	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	06-Apr-05	07-Apr-05	5040342	"	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Pond SA25987-04	889.00	Surface Water	02-Apr-05 12:45	04-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0578	0.00500 mg/l	1	ASTM D515-88(A)	05-Apr-05	05-Apr-05	5040181	AJ	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	06-Apr-05	07-Apr-05	5040342	"	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Out SA25987-05	889.00	Surface Water	02-Apr-05 13:00	04-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0241	0.00500 mg/l	1	ASTM D515-88(A)	05-Apr-05	05-Apr-05	5040181	AJ	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	06-Apr-05	07-Apr-05	5040342	"	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Dup SA25987-06	889.00	Surface Water	02-Apr-05 00:00	04-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0847	0.00500 mg/l	1	ASTM D515-88(A)	05-Apr-05	05-Apr-05	5040181	AJ	
	Total Suspended Solids	30.0	5.00 mg/l	1	SM2540D	06-Apr-05	07-Apr-05	5040342	"	

General Chemistry Parameters - Quality Control

Analyte(s)	Result	*RDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch 5040181 - General Preparation										
Blank (5040181-BLK1)				Prepared & Analyzed: 05-Apr-05						
Phosphorus as P	BRL	0.00500	mg/l							
Blank (5040181-BLK2)				Prepared & Analyzed: 05-Apr-05						
Phosphorus as P	BRL	0.00500	mg/l							
LCS (5040181-BS1)				Prepared & Analyzed: 05-Apr-05						
Phosphorus as P	0.246	0.00500	mg/l	0.250		98.4	90-110			
LCS (5040181-BS2)				Prepared & Analyzed: 05-Apr-05						
Phosphorus as P	0.241	0.00500	mg/l	0.250		96.4	90-110			
Reference (5040181-SRM1)				Prepared & Analyzed: 05-Apr-05						
Phosphorus as P	6.23	0.0500	mg/l	6.23		100	75.6-117			
Batch 5040342 - General Preparation										
Blank (5040342-BLK1)				Prepared: 06-Apr-05 Analyzed: 07-Apr-05						
Total Suspended Solids	BRL	5.00	mg/l							
Duplicate (5040342-DUP1)		**Source: SA25987-01**		Prepared: 06-Apr-05 Analyzed: 07-Apr-05						
Total Suspended Solids	41.0	5.00	mg/l		34.0			18.7	20	
Reference (5040342-SRM1)				Prepared: 06-Apr-05 Analyzed: 07-Apr-05						
Total Suspended Solids	94.0	5.00	mg/l	87.4		108	80-120			

Notes and Definitions

BRL	Below Reporting Limit - Analyte NOT DETECTED at or above the reporting limit
dry	Sample results reported on a dry weight basis
NR	Not Reported
RPD	Relative Percent Difference

A plus sign (+) in the Method Reference column indicates the method is not accredited by NELAC.

Laboratory Control Sample (LCS): A known matrix spiked with compound(s) representative of the target analytes, which is used to document laboratory performance.

Matrix Duplicate: An intra-laboratory split sample which is used to document the precision of a method in a given sample matrix.

Matrix Spike: An aliquot of a sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Method Blank: An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

Method Detection Limit (MDL): The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

Reportable Detection Limit (RDL): The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. For many analytes the RDL analyte concentration is selected as the lowest non-zero standard in the calibration curve. While the RDL is approximately 5 to 10 times the MDL, the RDL for each sample takes into account the sample volume/weight, extract/digestate volume, cleanup procedures and, if applicable, dry weight correction. Sample RDLs are highly matrix-dependent.

Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. These compounds are spiked into all blanks, standards, and samples prior to analysis. Percent recoveries are calculated for each surrogate.

Validated by:
Hanibal C. Tayeh, Ph.D.
Nicole Brown

SA25987 MM

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

CHAIN OF CUSTODY RECORD

Page 1 of 1

Special Handling:
- ☒ Standard TAT - 7 to 10 business days
- ☐ Rush TAT - Date Needed: ______
- All TATs subject to laboratory approval. Min. 24-hour notification needed for rushes.
- Samples disposed of after 60 days unless otherwise instructed.

Report To: Lisa Lyons
CDW Consultants, Inc.
40 Speen St., Suite 301
Framingham, MA 01701

Project Mgr.: Lisa Lyons

Invoice To: Same
IW# 5004421 (DH)

P.O. No.: ______ RQN: ______

Project No.: 889.00
Site Name: Acton Wetland
Location: Acton State: MA
Sampler(s): L. Lyons, K. Campbell

1=$Na_2S_2O_3$ 2=HCl 3=H_2SO_4 4=HNO_3 5=NaOH 6=Ascorbic Acid
7=CH_3OH 8=$NaHSO_4$ 9=______ 10=______

DW=Drinking Water GW=Groundwater WW=Wastewater
O=Oil SW= Surface Water SO=Soil SL=Sludge A=Air
X1=______ X2=______ X3=______

G=Grab C=Composite

Lab Id:	Sample Id:	Date:	Time:	Type	Matrix	Preservative	# of VOA Vials	# of Amber Glass	# of Clear Glass	# of Plastic	Total Suspended Solids*	Nitrate Nitrogen	Total Phosphorus
25987-01	IN-1	4/2/05	12:05PM	G	SW	3				2	X	X	X
-02	IN-3	↓	12:15PM	↓	↓	3				↓	↓	↓	↓
03	IN-2	↓	12:30PM	↓	↓	3				↓	↓	↓	↓
04	POND	↓	12:45PM	↓	↓	3				↓	↓	↓	↓
05	~~POOL~~	↓	1:00PM	↓	↓	3				↓	↓	↓	↓
06	DUP	↓	—	↓	↓	3				↓	↓	↓	↓

Analyses:

QA Reporting Notes: (check if needed)

State specific reporting standards *If applicable, please list below.*

☐ Provide MCP CAM Report
Were all field QC requirements met as per MADEP CAM Section 2.0?
☐ Yes ☐ No
(Response required for CAM report)

*Note: If holding time is exceeded for Nitrate-Nitrogen samples, DO NOT RUN per client instructions.

☐ Fax results when available to (____)
☒ E-mail to llyons@cdwconsultants.com
EDD Format ______

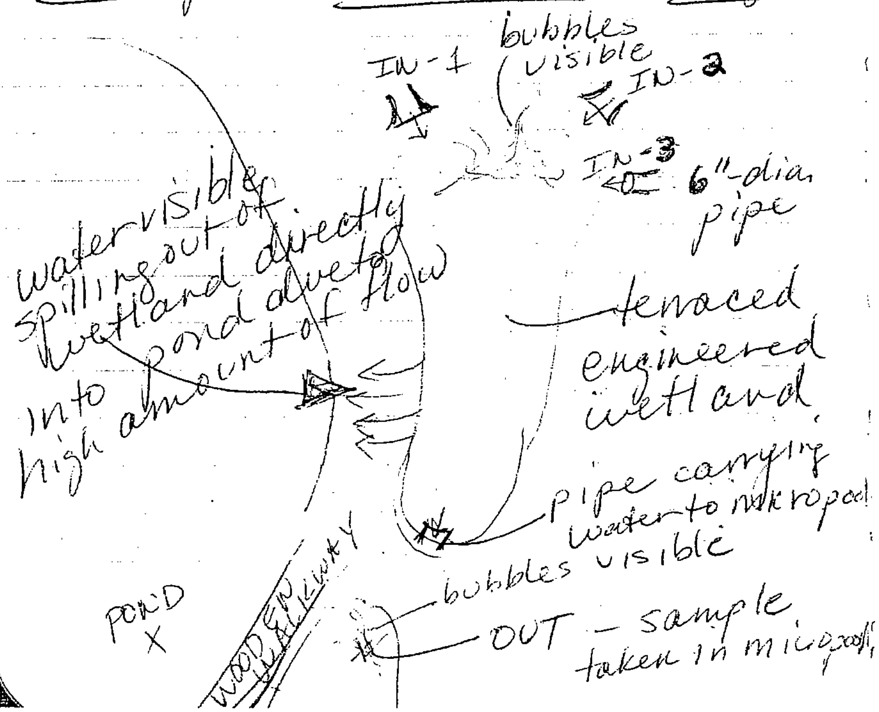
Relinquished by:	Received by:	Date:	Time:
[signature]	Bill Hastings	4/4/05	1010
Bill Hastings	[signature]	4/4/05	1525

Condition upon receipt: ☐ Iced ☐ Ambient ☐ °C 2

4/2/05 889.00 Acton Stormwater p. 1 of 6
Purpose: Recirculation Pond Sampling
L. Lyons, K. Campbell, CDW 40°, rainy

11:30 AM Arrived at site and began looking for pipes ~~upgradient~~ stream from the outfalls entering the engineered wetland, so that we could try to measure flow in pipes rather than flat outfalls. Didn't locate any pipes that could help.

Sample Location Diagram:



4/2/05 889.00 Acton Stormwater p. 2 of 6
Purpose: Recirculation Pond Sampling
L. Lyons, K. Campbell, CDW 40°, rainy

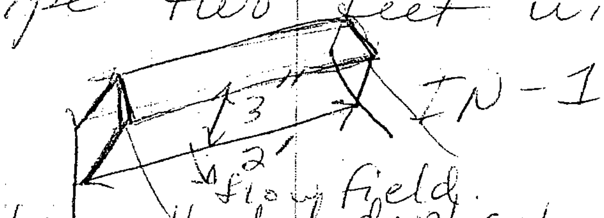
A growing number of bubbles are visible in the water where the 3 outfalls are bringing water into the wetland area. Strings of small bubbles - could indicate phosphorus content is high.
Also noted that water is flowing over the side of the engineered wetland and directly into the pond, due to the high amount of flow through the wetland. This water is therefore bypassing the micropool. We found the pipe in the engineered wetland that carries water underground and into the micropool. Could not find the outlet of this pipe in

the micropool, it is apparently underwater. Water levels in the pond and micropool are very high, water in pond is approaching the lifeguard chairs.

Since outlet pipe into the micropool isn't visible, we will sample the micropool water above where we believe the outlet pipe should be. We can see the same strings of small bubbles in this area that we see at the top of the engineered wetlands, so it is likely that this water with bubbles came through the wetlands quickly in the storm and was released into the micropool.

Samples preserved as follows:
Total Phosphorus — 4°C, H_2SO_4
Total Susp. Solids and Nitrate-Nitrogen — 4°C

12:05 PM Sampled IN-1: Flow was 3 inches deep in an area of the outfall pipe that was a flat pipe two feet wide.

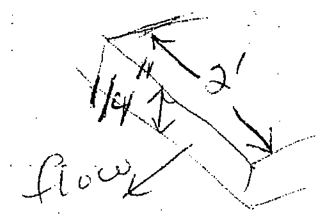


* Also collected duplicate here. Very heavy flow — looks like at least 100 gpm. This pipe looks like the source of the bubbles in the water in this area. Collected samples ~~from~~ for Total Phosphorus, Nitrate-Nitrogen, and Total Suspended Solids.

12:15 PM Sampled IN-3. Flow is 4½" deep in 6" dia pipe, but pipe is partially submerged so accurate measurement

4/2/05 889.00 Acton Stormwater. 5 of 6
Purpose: Recirculation Pond Sampling
L. Lyons, K. Campbell, CDW 40° raining

of depth of flow isn't possible. Sampled flowing water on top of water ~~in~~ exiting pipe for Total Phosphorus, Total Suspended Solids and Nitrate-Nitrogen.
12:30 PM Sampled IN-2. Water flow was 1/4" deep where flat pipe was 2 feet wide.



Collected samples for Total Suspended Solids, Total Phosphorus, and Nitrate-Nitrogen.
12:45 PM Collected a sample in the pond (POND) near the center of the wooden walkway dividing the pond and micropool. Collected

4/2/05 889.00 Acton Stormwater. 6 of 6
Purpose: Recirculation Pond Sampling
L. Lyons, K. Campbell, CDW 40° raining

samples for Total Phosphorus, Nitrate-Nitrogen, and Total Suspended Solids. No flow measurable.
1:00 PM Collected sample OUT in micropool above the location where we believe the outlet pipe from the wetlands is beneath the water.
Collected samples for Total Phosphorus, Nitrate-Nitrogen, Total Suspended Solids. Since pipe was submerged, no flow could be measured.
All samples placed on ice.
Off-site at 1:15 PM.

Lisa Lyons

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

INVOICE

Date: April 14, 2005

Invoice Number: 5004421
Work Order No.: SA25987

To: CDW Consultants, Inc.
40 Speen Street; Suite 301
Framingham, MA 01701
Attn: Accounts Payable

Purchase Order No.: NA   /Task /Acct.   **RQN #:** NA
Client Project No.: 889.00 / 6 /618.00   **Site Location:** Acton Wetland - Acton, MA
A. Lyons 4/20/05

The following charges are due for the above indicated samples submitted on 4/4/05.

Matrix	Analysis	Quantity	Unit Price	Total Price
Aqueous	Total Phosphorus by ASTM	6	$14.00	$84.00
Aqueous	Total Suspended Solids	6	$9.00	$54.00
Credit for Duplicate		-1	$23.00	($23.00)
TOTAL AMOUNT DUE FOR SERVICES:				**$115.00**

Please remit payment to: Spectrum Analytical, Inc.
11 Almgren Drive
Agawam, MA 01001

Your prompt payment is greatly appreciated. Thank you for your business!

Payment Terms: Net 30 Days

ENVIRONMENTAL ANALYSES
11 Almgren Drive • Agawam, Massachusetts 01001 • Operational Building & Sample Receiving
830 Silver Street • Agawam, Massachusetts 01001 • Administrative Offices, Volatile & Air Departments
1-800-789-9115 • 413-789-9018 • Fax 413-789-4076

Report Date:
06-May-05 15:25

☑ Final Report
☐ Re-Issued Report
☐ Revised Report

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

Laboratory Report

CDW Consultants, Inc.
40 Speen Street; Suite 301
Framingham, MA 01701
Attn: Lisa Lyons

Project: Acton Recirculation Pond - Acton, MA
Project #: 889.00

Laboratory ID	Client Sample ID	Matrix	Date Sampled	Date Received
SA26977-01	IN-1	Surface Water	24-Apr-05 07:00	25-Apr-05 14:05
SA26977-02	IN-2	Surface Water	24-Apr-05 07:30	25-Apr-05 14:05
SA26977-03	IN-3	Surface Water	24-Apr-05 07:20	25-Apr-05 14:05
SA26977-04	OUT	Surface Water	24-Apr-05 07:45	25-Apr-05 14:05
SA26977-05	POND	Surface Water	24-Apr-05 08:05	25-Apr-05 14:05
SA26977-06	DUP	Surface Water	24-Apr-05 00:00	25-Apr-05 14:05

I attest that the information contained within the report has been reviewed for accuracy and checked against the quality control requirements for each method. All applicable NELAC requirements have been met.
Please note that this report contains 6 pages of analytical data plus Chain of Custody document(s).

Massachusetts Certification # M-MA138/MA1110
Connecticut # PH-0777
Florida # E87600/E87936
Maine # MA138
New Hampshire # 2538/2972
New York # 11393/11840
Rhode Island # 98
USDA # S-51435
Vermont # VT-11393

ACCREDITED IN ACCORDANCE WITH nelac

Authorized by:

Hanibal C. Tayeh, Ph.D.
President/Laboratory Director

Spectrum Analytical, Inc. is a NELAC accredited laboratory organization and meets NELAC testing standards. Use of the NELAC logo however does not insure that Spectrum is currently accredited for the specific method indicated. Please refer to our "Quality" webpage at www.spectrum-analytical.com for a full listing of our current certifications.

11 Almgren Drive • Agawam, Massachusetts 01001 • Operational Building & Sample Receiving
830 Silver Street • Agawam, Massachusetts 01001 • Administrative Offices, Volatile & Air Departments
1-800-789-9115 • 413-789-9018 • Fax 413-789-4076

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-1 SA26977-01	889.00	Surface Water	24-Apr-05 07:00	25-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0147	0.00500 mg/l	1	ASTM D515-88(A)	28-Apr-05	28-Apr-05	5041623	AJ	
	Nitrate as N	BRL	0.100 mg/l	1	EPA 300.0	25-Apr-05 15:00	26-Apr-05	5041422	AW	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	25-Apr-05	25-Apr-05	5041353	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-2 SA26977-02	889.00	Surface Water	24-Apr-05 07:30	25-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0302	0.00500 mg/l	1	ASTM D515-88(A)	28-Apr-05	28-Apr-05	5041623	AJ	
	Nitrate as N	0.270	0.100 mg/l	1	EPA 300.0	25-Apr-05 15:00	26-Apr-05	5041422	AW	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	25-Apr-05	25-Apr-05	5041353	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-3 SA26977-03	889.00	Surface Water	24-Apr-05 07:20	25-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	BRL	0.00500 mg/l	1	ASTM D515-88(A)	28-Apr-05	28-Apr-05	5041623	AJ	
	Nitrate as N	0.240	0.100 mg/l	1	EPA 300.0	25-Apr-05 15:00	26-Apr-05	5041422	AW	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	25-Apr-05	25-Apr-05	5041353	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
OUT SA26977-04	889.00	Surface Water	24-Apr-05 07:45	25-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0250	0.00500 mg/l	1	ASTM D515-88(A)	28-Apr-05	28-Apr-05	5041623	AJ	
	Nitrate as N	BRL	0.100 mg/l	1	EPA 300.0	25-Apr-05 15:00	26-Apr-05	5041422	AW	
	Total Suspended Solids	8.00	5.00 mg/l	1	SM2540D	25-Apr-05	25-Apr-05	5041353	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
POND SA26977-05	889.00	Surface Water	24-Apr-05 08:05	25-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0764	0.00500 mg/l	1	ASTM D515-88(A)	28-Apr-05	28-Apr-05	5041623	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
DUP SA26977-06	889.00	Surface Water	24-Apr-05 00:00	25-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0216	0.00500 mg/l	1	ASTM D515-88(A)	28-Apr-05	28-Apr-05	5041623	AJ	
	Nitrate as N	BRL	0.100 mg/l	1	EPA 300.0	25-Apr-05 15:00	26-Apr-05	5041422	AW	HT-3
	Total Suspended Solids	10.0	5.00 mg/l	1	SM2540D	25-Apr-05	25-Apr-05	5041353	AJ	

Analyte(s)	Result	*RDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch 5041353 - General Preparation										
Blank (5041353-BLK1)				Prepared & Analyzed: 25-Apr-05						
Total Suspended Solids	BRL	5.00	mg/l							
Duplicate (5041353-DUP1)		**Source: SA26848-01**		Prepared & Analyzed: 25-Apr-05						
Total Suspended Solids	37.0	5.00	mg/l		41.0			10.3	20	
Duplicate (5041353-DUP2)		**Source: SA26913-02**		Prepared & Analyzed: 25-Apr-05						
Total Suspended Solids	716	20.0	mg/l		696			2.83	20	
Duplicate (5041353-DUP3)		**Source: SA26947-04**		Prepared & Analyzed: 25-Apr-05						
Total Suspended Solids	278	5.00	mg/l		279			0.359	20	
Reference (5041353-SRM1)				Prepared & Analyzed: 25-Apr-05						
Total Suspended Solids	89.0	5.00	mg/l	88.5		101	80-120			
Batch 5041422 - General Preparation										
Blank (5041422-BLK1)				Prepared & Analyzed: 25-Apr-05						
Nitrate as N	BRL	0.100	mg/l							
Blank (5041422-BLK2)				Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	BRL	0.100	mg/l							
LCS (5041422-BS1)				Prepared & Analyzed: 25-Apr-05						
Nitrate as N	1.93	0.100	mg/l	2.00		96.5	90-110			
LCS (5041422-BS2)				Prepared & Analyzed: 25-Apr-05						
Nitrate as N	0.380	0.100	mg/l	0.400		95.0	90-110			
LCS (5041422-BS3)				Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	2.06	0.100	mg/l	2.00		103	90-110			
LCS (5041422-BS4)				Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	0.370	0.100	mg/l	0.400		92.5	90-110			
Duplicate (5041422-DUP2)		**Source: SA26977-03**		Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	0.200	0.100	mg/l		0.240			18.2	20	
Matrix Spike (5041422-MS2)		**Source: SA26977-03**		Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	0.620	0.100	mg/l	0.400	0.240	95.0	80-120			
Matrix Spike Dup (5041422-MSD2)		**Source: SA26977-03**		Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	0.610	0.100	mg/l	0.400	0.240	92.5	80-120	1.63	20	
Reference (5041422-SRM1)				Prepared & Analyzed: 25-Apr-05						
Nitrate as N	2.25	0.100	mg/l	2.50		90.0	90-110			
Reference (5041422-SRM2)				Prepared & Analyzed: 25-Apr-05						
Nitrate as N	0.460	0.100	mg/l	0.500		92.0	90-110			
Reference (5041422-SRM3)				Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	2.43	0.100	mg/l	2.50		97.2	90-110			
Reference (5041422-SRM4)				Prepared: 25-Apr-05 Analyzed: 26-Apr-05						
Nitrate as N	0.490	0.100	mg/l	0.500		98.0	90-110			
Batch 5041623 - General Preparation										
Blank (5041623-BLK1)				Prepared & Analyzed: 28-Apr-05						
Phosphorus as P	BRL	0.00500	mg/l							
Blank (5041623-BLK2)				Prepared & Analyzed: 28-Apr-05						
Phosphorus as P	BRL	0.00500	mg/l							
LCS (5041623-BS1)				Prepared & Analyzed: 28-Apr-05						
Phosphorus as P	0.253	0.00500	mg/l	0.250		101	90-110			
LCS (5041623-BS2)				Prepared & Analyzed: 28-Apr-05						

General Chemistry Parameters - Quality Control

Analyte(s)	Result	*RDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch 5041623 - General Preparation										
LCS (5041623-BS2)				Prepared & Analyzed: 28-Apr-05						
Phosphorus as P	0.246	0.00500	mg/l	0.250		98.4	90-110			
Duplicate (5041623-DUP1)		**Source: SA26977-02**		Prepared & Analyzed: 28-Apr-05						
Phosphorus as P	0.0250	0.00500	mg/l		0.0302			18.8	20	
Matrix Spike (5041623-MS1)		**Source: SA26977-02**		Prepared & Analyzed: 28-Apr-05						
Phosphorus as P	0.266	0.00500	mg/l	0.250	0.0302	94.3	80-120			
Reference (5041623-SRM1)				Prepared & Analyzed: 28-Apr-05						
Phosphorus as P	6.23	0.0500	mg/l	6.23		100	75.6-117			

Notes and Definitions

HT-3	The collection time was not indicated on the chain of custody. Therefore, the analysis hold time can not be verified.
BRL	Below Reporting Limit - Analyte NOT DETECTED at or above the reporting limit
dry	Sample results reported on a dry weight basis
NR	Not Reported
RPD	Relative Percent Difference

A plus sign (+) in the Method Reference column indicates the method is not accredited by NELAC.

Laboratory Control Sample (LCS): A known matrix spiked with compound(s) representative of the target analytes, which is used to document laboratory performance.

Matrix Duplicate: An intra-laboratory split sample which is used to document the precision of a method in a given sample matrix.

Matrix Spike: An aliquot of a sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Method Blank: An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

Method Detection Limit (MDL): The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

Reportable Detection Limit (RDL): The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. For many analytes the RDL analyte concentration is selected as the lowest non-zero standard in the calibration curve. While the RDL is approximately 5 to 10 times the MDL, the RDL for each sample takes into account the sample volume/weight, extract/digestate volume, cleanup procedures and, if applicable, dry weight correction. Sample RDLs are highly matrix-dependent.

Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. These compounds are spiked into all blanks, standards, and samples prior to analysis. Percent recoveries are calculated for each surrogate.

Validated by:
Hanibal C. Tayeh, Ph.D.
Nicole Brown

SA26977

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

CHAIN OF CUSTODY RECORD

Page 1 of 1

Special Handling:

- ☒ Standard TAT - 7 to 10 business days
- ☐ Rush TAT - Date Needed: ______
- All TATs subject to laboratory approval. Min. 24-hour notification needed for rushes.
- Samples disposed of after 60 days unless otherwise instructed.

Report To: Lisa Lyons
CDW Consultants Inc.
40 Speen St, Suite 301
Framingham, MA 01701
Project Mgr.: Lisa Lyons

Invoice To: Same
IW#5005639 (LH)
P.O. No.: ______ RQN: ______

Project No.: 889.00
Site Name: Acton Recirculation Pond
Location: Acton State: MA
Sampler(s): L. Lyons

1=$Na_2S_2O_3$ 2=HCl 3=H_2SO_4 4=HNO_3 5=NaOH 6=Ascorbic Acid
7=CH_3OH 8=$NaHSO_4$ 9= 4°C 10=______

DW=Drinking Water GW=Groundwater WW=Wastewater
O=Oil SW= Surface Water SO=Soil SL=Sludge A=Air
X1=______ X2=______ X3=______

G=Grab C=Composite

Lab Id:	Sample Id:	Date:	Time:	Type	Matrix	Preservative	# of VOA Vials	# of Amber Glass	# of Clear Glass	# of Plastic	Total Phosphorus	* Nitrate-Nitrogen	Total Suspended Solids
SA26977-01	IN-1	4/24/05	7:00AM	G	SW	3,9				2	X	X	X
-02	IN-2	↓	7:30AM	↓	↓	↓				2	X	X	X
-03	IN-3	↓	7:20AM	↓	↓	↓				2	X	X	X
-04	OUT	↓	7:45AM	↓	↓	↓				2	X	X	X
-05	POND	↓	8:05AM	↓	↓	↓				1	X		
-06	DUP	↓	—	↓	↓	↓				2	X	X	X

QA Reporting Notes: (check if needed)

State specific reporting standards *If applicable, please list below.*

☐ Provide MCP CAM Report
Were all field QC requirements met as per MADEP CAM Section 2.0? ☐ Yes ☐ No
(Response required for CAM report)

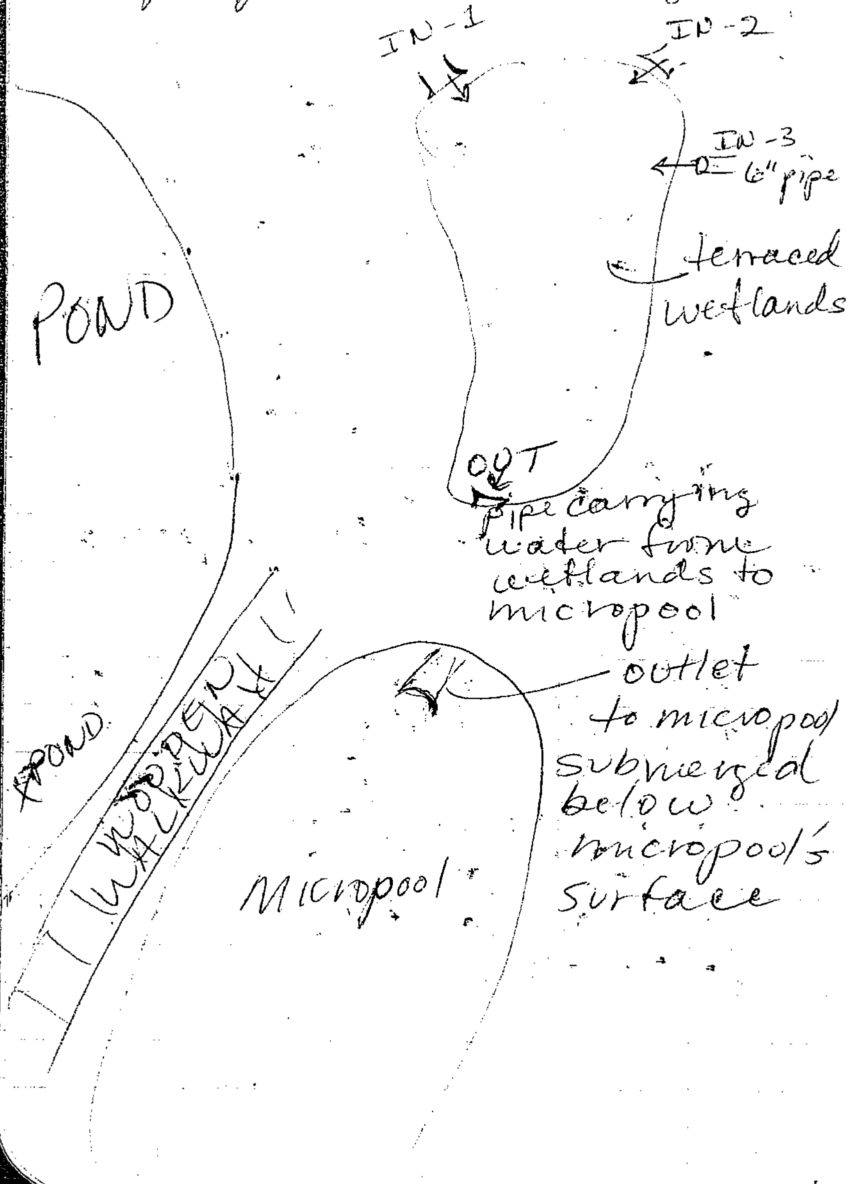
* Note: If holding time is exceeded for Nitrate-Nitrogen samples, do not run that analysis.

☐ Fax results when available to (____)
☒ E-mail to llyons@cdwconsultants.com
EDD Format ______

Condition upon receipt: ☐ Iced ☐ Ambient ☐ °C 4

Relinquished by:	Received by:	Date:	Time:
[signature]	[signature]	4/25/05	12:25
[signature]	[signature]	4/25/05	14:05

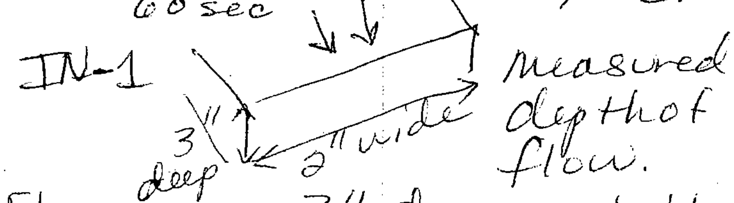
4/24/05 889.00 Acton Recirculation Pond Sampling p. 1 of 4
Lisa Lyons, CDW 45°, Raining
Sampling location diagram.



4/24/05 889. Acton Recirculation Pond Sampling p. 2 of 4
L. Lyons, CDW 45°, Raining

7:00 AM Measured flow with Global Flow probe and sampled at IN-1.
Flow velocity = 5.2 mi/hr.

$= 5.2 \frac{miles}{hr} \times \frac{5,280 ft}{mi} \times \frac{1 hr}{60 min} \times \frac{1 min}{60 sec} = 7.6$ ft/sec.



Flow was 3" deep at the point where the pipe was 2' wide.

7:20 AM Set sampling container under edge of pipe at IN-2. Low flow means container will fill slowly, so I move on to IN-3 while the container is filling.

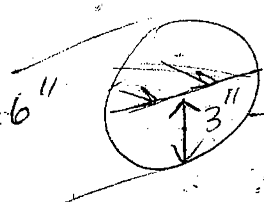
4/24/05 889.00 Acton p. 3 of 4
Recirculation Pond Sampling
L. Lyons, CDW 45°, raining

Flow at IN-3 =

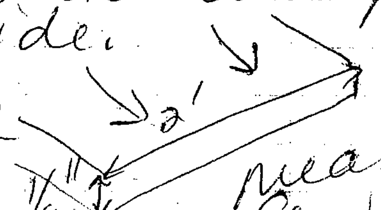
$1.2\frac{mi}{hr} \times \frac{5280ft}{mi} \times \frac{1hr}{60min} \times \frac{1min}{60sec}$

= 1.76 ft/sec.

Flow was 3" deep in the 6"-dia. ~~re~~ pipe.

D=6"

3"
measured depth of flow

7:30 AM Finished filling sample containers at IN-2. Flow was so low it could not be measured with the flow probe. Measured 1/8" deep water where pipe was 2' wide.

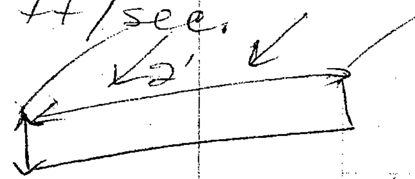
IN-2

2'
1/8"
measured flow depth and width

4/24/05 889.00 Acton p. 4 of 4
Recirculation Pond Sampling
L. Lyons, CDW 45°, raining

7:45 AM Outlet pipe into micropool was visible beneath water surface. Sampled water flowing into feed pipe to micropool instead. Flow =

$5.3\frac{mi}{hr} \times \frac{5280ft}{mi} \times \frac{1hr}{60min} \times \frac{1min}{60sec}$

= 7.8 ft/sec.

OUT

2'
2"

Duplicate sample collected at OUT location.

8:05 AM Sampled pond for Total Phosphorus only. All other samples will be submitted for Total Phosphorus, Total Suspended Solids, and Nitrate-Nitrogen off-site @ 8:30 AM.

Lisa Lyons

Report Date:
10-May-05 14:44

☐ Final Report
☐ Re-Issued Report
☐ Revised Report

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

Laboratory Report

CDW Consultants, Inc.
40 Speen Street; Suite 301
Framingham, MA 01701
Attn: Lisa Lyons

Project: Acton Recirculation Pond - Acton, MA
Project #: 889.00

Laboratory ID	Client Sample ID	Matrix	Date Sampled	Date Received
SA27174-01	IN-1	Surface Water	27-Apr-05 17:45	28-Apr-05 15:30
SA27174-02	IN-2	Surface Water	27-Apr-05 17:30	28-Apr-05 15:30
SA27174-03	IN-3	Surface Water	27-Apr-05 17:15	28-Apr-05 15:30
SA27174-04	OUT	Surface Water	27-Apr-05 18:00	28-Apr-05 15:30
SA27174-05	POND	Surface Water	27-Apr-05 18:15	28-Apr-05 15:30
SA27174-06	DUP	Surface Water	27-Apr-05 00:00	28-Apr-05 15:30

I attest that the information contained within the report has been reviewed for accuracy and checked against the quality control requirements for each method. All applicable NELAC requirements have been met.
Please note that this report contains 7 pages of analytical data including Chain of Custody document(s).

Massachusetts Certification # M-MA138/MA1110
Connecticut # PH-0777
Florida # E87600/E87936
Maine # MA138
New Hampshire # 2538/2972
New York # 11393/11840
Rhode Island # 98
USDA # S-51435
Vermont # VT-11393

Authorized by:

Hanibal C. Tayeh, Ph.D.
President/Laboratory Director

Spectrum Analytical, Inc. is a NELAC accredited laboratory organization and meets NELAC testing standards. Use of the NELAC logo however does not insure that Spectrum is currently accredited for the specific method indicated. Please refer to our "Quality" webpage at www.spectrum-analytical.com for a full listing of our current certifications.

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-1 SA27174-01	889.00	Surface Water	27-Apr-05 17:45	28-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.00700	0.00500 mg/l	1	ASTM D515-88(A)	06-May-05	06-May-05	5050488	AW	
	Nitrate as N	BRL	0.100 mg/l	1	EPA 300.0	28-Apr-05 10:00	29-Apr-05	5041691	"	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	04-May-05	04-May-05	5050206	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-2 SA27174-02	889.00	Surface Water	27-Apr-05 17:30	28-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0260	0.00500 mg/l	1	ASTM D515-88(A)	06-May-05	06-May-05	5050488	AW	
	Nitrate as N	0.210	0.100 mg/l	1	EPA 300.0	28-Apr-05 10:00	29-Apr-05	5041691	"	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	04-May-05	04-May-05	5050206	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
IN-3 SA27174-03	889.00	Surface Water	27-Apr-05 17:15	28-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	BRL	0.00500 mg/l	1	ASTM D515-88(A)	06-May-05	09-May-05	5050488	AW	
	Nitrate as N	0.260	0.100 mg/l	1	EPA 300.0	28-Apr-05 10:00	29-Apr-05	5041691	"	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	04-May-05	04-May-05	5050206	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
OUT SA27174-04	889.00	Surface Water	27-Apr-05 18:00	28-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0380	0.00500 mg/l	1	ASTM D515-88(A)	06-May-05	06-May-05	5050488	AW	
	Nitrate as N	BRL	0.100 mg/l	1	EPA 300.0	28-Apr-05 10:00	29-Apr-05	5041691	"	
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	04-May-05	04-May-05	5050206	AJ	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
POND SA27174-05	889.00	Surface Water	27-Apr-05 18:15	28-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.0350	0.00500 mg/l	1	ASTM D515-88(A)	06-May-05	06-May-05	5050488	AW	

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
DUP SA27174-06	889.00	Surface Water	27-Apr-05 00:00	28-Apr-05

CAS No.	*Analyte(s)*	*Result*	**RDL/Units*	*Dilution*	*Method Ref.*	*Prepared*	*Analyzed*	*Batch*	*Analyst*	*Flag*
General Chemistry Parameters										
7723-14-0	Phosphorus as P	0.00700	0.00500 mg/l	1	ASTM D515-88(A)	06-May-05	06-May-05	5050488	AW	
	Nitrate as N	BRL	0.100 mg/l	1	EPA 300.0	28-Apr-05 10:00	29-Apr-05	5041691	"	HT-3
	Total Suspended Solids	BRL	5.00 mg/l	1	SM2540D	04-May-05	04-May-05	5050206	AJ	

General Chemistry Parameters - Quality Control

Analyte(s)	Result	*RDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch 5041691 - General Preparation										
Blank (5041691-BLK1)				Prepared & Analyzed: 28-Apr-05						
Nitrate as N	BRL	0.100	mg/l							
Blank (5041691-BLK2)				Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	BRL	0.100	mg/l							
LCS (5041691-BS1)				Prepared & Analyzed: 28-Apr-05						
Nitrate as N	2.04	0.100	mg/l	2.00		102	90-110			
LCS (5041691-BS2)				Prepared & Analyzed: 28-Apr-05						
Nitrate as N	0.400	0.100	mg/l	0.400		100	90-110			
LCS (5041691-BS3)				Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	2.04	0.100	mg/l	2.00		102	90-110			
LCS (5041691-BS4)				Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.410	0.100	mg/l	0.400		102	90-110			
Duplicate (5041691-DUP1)		**Source: SA27167-03**		Prepared & Analyzed: 28-Apr-05						
Nitrate as N	0.360	0.100	mg/l		0.330			8.70	20	
Duplicate (5041691-DUP2)		**Source: SA27171-04**		Prepared & Analyzed: 28-Apr-05						
Nitrate as N	BRL	0.100	mg/l		0.0500			0.00	20	
Duplicate (5041691-DUP3)		**Source: SA27174-03**		Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.250	0.100	mg/l		0.260			3.92	20	
Duplicate (5041691-DUP4)		**Source: SA27184-06**		Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.430	0.100	mg/l		0.520			18.9	20	
Matrix Spike (5041691-MS1)		**Source: SA27167-03**		Prepared & Analyzed: 28-Apr-05						
Nitrate as N	0.790	0.100	mg/l	0.400	0.330	115	80-120			
Matrix Spike (5041691-MS2)		**Source: SA27171-04**		Prepared & Analyzed: 28-Apr-05						
Nitrate as N	0.430	0.100	mg/l	0.400	0.0500	95.0	80-120			
Matrix Spike (5041691-MS3)		**Source: SA27174-03**		Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.620	0.100	mg/l	0.400	0.260	90.0	80-120			
Matrix Spike (5041691-MS4)		**Source: SA27184-06**		Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.860	0.100	mg/l	0.400	0.520	85.0	80-120			
Matrix Spike Dup (5041691-MSD1)		**Source: SA27167-03**		Prepared & Analyzed: 28-Apr-05						
Nitrate as N	0.770	0.100	mg/l	0.400	0.330	110	80-120	2.56	20	
Matrix Spike Dup (5041691-MSD2)		**Source: SA27171-04**		Prepared & Analyzed: 28-Apr-05						
Nitrate as N	0.400	0.100	mg/l	0.400	0.0500	87.5	80-120	7.23	20	
Matrix Spike Dup (5041691-MSD3)		**Source: SA27174-03**		Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.600	0.100	mg/l	0.400	0.260	85.0	80-120	3.28	20	
Matrix Spike Dup (5041691-MSD4)		**Source: SA27184-06**		Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.880	0.100	mg/l	0.400	0.520	90.0	80-120	2.30	20	
Reference (5041691-SRM1)				Prepared & Analyzed: 28-Apr-05						
Nitrate as N	2.40	0.100	mg/l	2.50		96.0	90-110			
Reference (5041691-SRM2)				Prepared & Analyzed: 28-Apr-05						
Nitrate as N	0.500	0.100	mg/l	0.500		100	90-110			
Reference (5041691-SRM3)				Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	2.35	0.100	mg/l	2.50		94.0	90-110			
Reference (5041691-SRM4)				Prepared: 28-Apr-05 Analyzed: 29-Apr-05						
Nitrate as N	0.500	0.100	mg/l	0.500		100	90-110			
Batch 5050206 - General Preparation										

General Chemistry Parameters - Quality Control

Analyte(s)	Result	*RDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch 5050206 - General Preparation										
Blank (5050206-BLK1)				Prepared & Analyzed: 04-May-05						
Total Suspended Solids	BRL	5.00	mg/l							
Duplicate (5050206-DUP1)		**Source: SA27174-01**		Prepared & Analyzed: 04-May-05						
Total Suspended Solids	BRL	5.00	mg/l		BRL				20	
Duplicate (5050206-DUP2)		**Source: SA27352-04**		Prepared & Analyzed: 04-May-05						
Total Suspended Solids	13200	500	mg/l		13600			2.99	20	
Reference (5050206-SRM1)				Prepared & Analyzed: 04-May-05						
Total Suspended Solids	92.0	5.00	mg/l	88.5		104	80-120			
Batch 5050488 - General Preparation										
Blank (5050488-BLK1)				Prepared: 06-May-05 Analyzed: 09-May-05						
Phosphorus as P	BRL	0.00500	mg/l							
LCS (5050488-BS1)				Prepared: 06-May-05 Analyzed: 09-May-05						
Phosphorus as P	0.240	0.00500	mg/l	0.250		96.0	90-110			
Duplicate (5050488-DUP1)		**Source: SA27174-03**		Prepared: 06-May-05 Analyzed: 09-May-05						
Phosphorus as P	BRL	0.00500	mg/l		0.00190			0.00	20	
Matrix Spike (5050488-MS1)		**Source: SA27174-03**		Prepared: 06-May-05 Analyzed: 09-May-05						
Phosphorus as P	0.243	0.00500	mg/l	0.250	0.00190	96.4	80-120			
Reference (5050488-SRM1)				Prepared: 06-May-05 Analyzed: 09-May-05						
Phosphorus as P	6.32	0.0500	mg/l	6.23		101	75.6-117			

Notes and Definitions

HT-3 The collection time was not indicated on the chain of custody. Therefore, the analysis hold time can not be verified.

BRL Below Reporting Limit - Analyte NOT DETECTED at or above the reporting limit

dry Sample results reported on a dry weight basis

NR Not Reported

RPD Relative Percent Difference

A plus sign (+) in the Method Reference column indicates the method is not accredited by NELAC.

Laboratory Control Sample (LCS): A known matrix spiked with compound(s) representative of the target analytes, which is used to document laboratory performance.

Matrix Duplicate: An intra-laboratory split sample which is used to document the precision of a method in a given sample matrix.

Matrix Spike: An aliquot of a sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Method Blank: An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

Method Detection Limit (MDL): The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

Reportable Detection Limit (RDL): The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. For many analytes the RDL analyte concentration is selected as the lowest non-zero standard in the calibration curve. While the RDL is approximately 5 to 10 times the MDL, the RDL for each sample takes into account the sample volume/weight, extract/digestate volume, cleanup procedures and, if applicable, dry weight correction. Sample RDLs are highly matrix-dependent.

Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. These compounds are spiked into all blanks, standards, and samples prior to analysis. Percent recoveries are calculated for each surrogate.

Validated by:
Hanibal C. Tayeh, Ph.D.
Nicole Brown

SA27174 (m) (8)

SPECTRUM ANALYTICAL, INC.
Featuring
HANIBAL TECHNOLOGY

CHAIN OF CUSTODY RECORD

Page 1 of 1

Special Handling:
- ☒ Standard TAT - 7 to 10 business days
- ☐ Rush TAT - Date Needed: ______
- All TATs subject to laboratory approval. Min. 24-hour notification needed for rushes.
- Samples disposed of after 60 days unless otherwise instructed.

Report To: CDW Consultants, Inc
40 Speen St, Suite 301
Framingham, MA
01701

Invoice To: Same

Project Mgr.: ______

P.O. No.: ______ RQN: ______

Project No.: 889.00
Site Name: Acton Recirculation Pond
Location: Acton State: MA
Sampler(s): L. Lyons, B. Miller

1=Na$_2$S$_2$O$_3$ 2=HCl 3=H$_2$SO$_4$ 4=HNO$_3$ 5=NaOH 6=Ascorbic Acid
7=CH$_3$OH 8=NaHSO$_4$ 9= 4°C 10=______

DW=Drinking Water GW=Groundwater WW=Wastewater
O=Oil SW=Surface Water SO=Soil SL=Sludge A=Air
X1=______ X2=______ X3=______

G=Grab C=Composite

Lab Id:	Sample Id:	Date:	Time:	Type	Matrix	Preservative	# of VOA Vials	# of Amber Glass	# of Clear Glass	# of Plastic	Total Suspended Solids	Nitrate-Nitrogen*	Total Phosphorus	QA Reporting Notes
SA27174-01	IN-1	4/27/05	5:45pm	G	SW	3,9				2	X	X	X	*If Nitrate-N
-02	IN-2	↓	5:30pm	↓	↓	↓				2	X	X	X	holding time
-03	IN-3	↓	5:15 PM	↓	↓	↓				2	X	X	X	is exceeded,
-04	OUT	↓	6:00pm	↓	↓	↓				2	X	X	X	do not run
-05	POND	↓	6:15pm	↓	↓	↓				1			X	this
-06	DUP	↓	—	↓	↓	↓				3	X	X	X	analysis.

QA Reporting Notes: (check if needed)
State specific reporting standards: If applicable, please list below.
☐ Provide MCP CAM Report
Were all field QC requirements met as per MADEP CAM Section 2.0? ☐ Yes ☐ No
(Response required for CAM report)

☐ Fax results when available to (____)
☒ E-mail to llyons@cdwconsultants.com
EDD Format

Relinquished by:	Received by:	Date:	Time:
[signature]	[signature]	4/28/05	1137
[signature]	[signature]	4/28/05	330

Condition upon receipt: ☐ Iced ☐ Ambient ☒ °C 2

in refrigerator

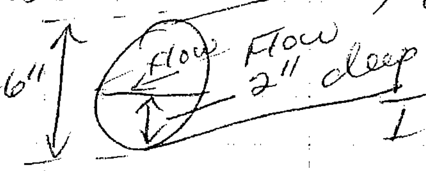
11 Almgren Drive • Agawam, Massachusetts 01001 • 413-789-9018 • Fax 413-789-4076 • www.spectrum-analytical.com

4/27/05
Recirculation Pond Sampling
L. Lyons, B. Miller - CDW 50°, raining

Sampling locations used today will be identical to those used on 4/24/05. See diagram in 4/24/05 field notes.

5:15 PM Sampled IN-3 for Total Phosphorus, Nitrate-Nitrogen and Total Suspended Solids. All samples but POND, which will be submitted for Total P only, are to be submitted for these analyses.

Measured flow 2" deep in 6"-dia. pipe. Measured velocity as 1.7 mi/hr or 2.5 ft/sec.

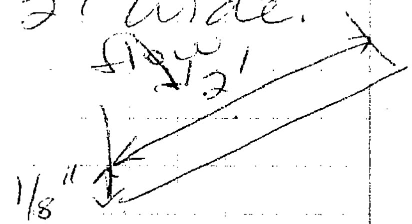


IN-3

5:30 PM Sampled IN-2. Flow too slow and water not deep enough to use flow meter.

4/27/05
Recirculation Pond Sampling
L. Lyons, B. Miller, CDW 50°, raining

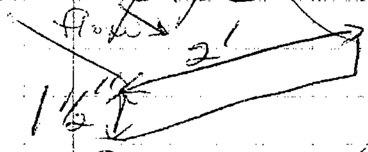
Flowing water only 1/8" deep where pipe is 2' wide.



IN-2

5:45 PM Sampled IN-1. Measured velocity as 2.71 mi/hr or 3.97 ft/sec.

Flow was 1½" deep at point where pipe is 2' wide.



IN-1

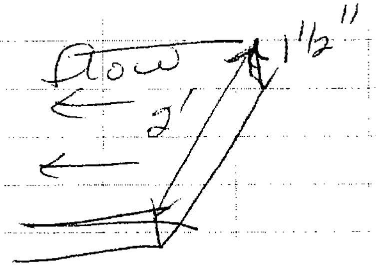
6:00 PM Sampled outlet to micropool - sample OUT.

As during last sampling round, end of pipe discharging to micropool was submerged.

4/27/05 [illegible]
Recirculation Pond Sampling
L. Lyons, B. Miller, CDW 50° raining
Sampled other end of this pipe, where water enters pipe at bottom of engineered wetlands, instead.
Measured velocity as 4.5 mi/hr or 6.6 ft/sec, flow 1½" deep where pipe is 2" wide.

OUT

← micropool



6:15 PM Sampled POND.

Note - duplicate sample (DUP) collected at IN-1 for QA/QC purposes.

Off-site at 6:35 PM.

Lisa Lyons

APPENDIX B: NONSTRUCTURAL BMPS MEETING MINUTES

203719.01
Acton 319 NPS

WOODARD & CURRAN
Engineering • Science • Operations

CORPORATE OFFICES: Maine, Massachusetts,
New Hampshire, Connecticut, Illinois, Florida
Operational offices throughout the U.S.

~~DEP~~
nonstructural BMPs (A5)

May 31, 2002

Mr. Brian Duval
DEP
627 Main Street, 2nd Floor
Worcester, MA 01608

RE: Town of Acton Nonpoint Source Control Program
Project 00-07/319
Federal Grant ID Number BG991878-97

Dear Mr. Duval:

On behalf of the Town of Acton, Woodard & Curran Inc. is submitting meeting minutes and questionnaires from meetings held with representatives from five (5) Acton departments, including the Highway Department, the Natural Resources Department, the Engineering Department, the Building Department and the Board of Health.

Each department was presented with a questionnaire prior to the meeting that inquired as to activities or functions within that department related to nonstructural BMPs and stormwater management. The meetings were a follow-up to those questionnaires. This submittal fulfills requirements of Item A under Task A5 of the Town of Acton Nonpoint Source Control Program (Project 00-07/319).

If you have any questions and/or comments concerning this submittal, please contact me at (978) 557-8150 (Ext. 3615).

Very truly yours,

WOODARD & CURRAN INC.

Robert J. Rafferty

Robert J. Rafferty, P.E.
Project Manager

Enclosure

cc: Jane Peirce, 319 Program Coordinator
Doug Halley, Town of Acton
David Senus, W&C
Helen Priola, W&C

WOODARD & CURRAN
Engineering • Science • Operations

MEMORANDUM

TO: Doug Halley

FROM: Bob Rafferty

DATE: April 8, 2002

RE: Draft Summary of Town Department Meetings

CC: David Senus
Helen Priola
File 203719.01

This memorandum presents our notes from meetings held with various Town departments regarding non-structural stormwater BMPs (practices and procedures for stormwater pollution control). On January 25, 2002, Bob Rafferty and David Senus joined you to meet with the following department representatives:

- Dave Brown, Highway Superintendent
- Tom Tidman, Natural Resources Director
- David Abbt, Engineering Administrator
- Garry Rhodes, Building Commissioner

The meetings were conducted to satisfy the requirements of the *Nonpoint Source Control Program* being implemented within the Town of Acton. The following tasks are listed under Task A5 of the DEP's Scope of Services for the *Town of Acton Nonpoint Source Control Program*:

A. Conduct review of current practices by meeting with Town Departments that have a role in watershed protection, including Planning, Engineering, Health, Conservation and Highway
B. Develop recommendations for policy or practice improvements…
C. Provide a Comprehensive Stormwater BMP Manual for use by the Town…

To comply with the subtasks listed above, Woodard & Curran Inc. prepared questionnaires that were designed to determine the extent of current non-structural stormwater management techniques currently implemented by Town departments.

The questionnaires are attached. These questionnaires were distributed on December 17, 2001 to the following departments:

- Highway
- Natural Resources
- Engineering
- Building
- Board of Health
- Planning

Meeting with the Town departments provided feedback on the questionnaires. Additionally, interacting with the department representatives on a personal basis allowed for a greater level of explanation and understanding of both the 319 project and the current or anticipated stormwater management practices used by each department.

Our findings can be generalized into three points:

1. Despite the coordinated process for review of new construction, there is no single entity responsible for stormwater issues. Each town department has its own set of distinct responsibilities.

2. Current regulations/bylaws/ordinances do not provide enough power of enforcement for stormwater regulations and basic maintenance of private systems. The Town should implement stormwater bylaws establishing the requirements for operation and maintenance of storm drains regardless of the discharge location (public or private property). The existing bylaws do not provide an avenue of legal enforcement for discharges to private property.

3. The Town should develop a firm schedule and map of catch basin cleaning and storm drain outfall clearing.

The Town's upcoming submittal of a Notice of Intent (Stormwater Management Plan) for the EPA Phase II Stormwater regulations will address these issues. Pending your review, we will follow up this memorandum with specific recommendations for policy or practice improvements and provide a Comprehensive Stormwater BMP Manual for use by the Town.

Department: Highway
Representative: Dave Brown, Highway Superintendent

- Schedule of maintenance on storm drain system? – Maintenance is performed at known problem areas and on areas where problems are arising. The Highway staff scouts outfalls in late winter / early spring and prioritizes maintenance outfall clearing based on visual observations and complaints. Flushing is not typically performed. The Town has a 2-inch fire hose with a nozzle for emergencies and borrows Concord's sewer jetter if needed.
- Mapped locations of the maintained drainage structures? – No set schedule for maintenance and no maps. Structures are maintained based on problem areas.
- Specific information on access problems (easements)? – There are no significant problems accessing the drainage structures or outfalls.
- Catch basins are cleaned using highway crews and a clamshell. All catch basins are cleaned yearly. They start with reported and observed problems first and then proceed with a normal rotation.
- Catch basin waste is stored in North Acton and combined with leaves and soil from roadside construction. Trimmings, clippings and general yard waste are added to make compost. Christmas trees are burned. The Town does not want tree ornaments and tinsel in compost. The Town does not actively advertise recycling of yard waste. Compost is used on baseball fields, etc. They have a screener.
- Town owns 1 street sweeper (mechanical brush style sweeper). The Town also rents from A+ Sweepers and pays by the hour for the sweeping services. The contract is bid yearly and can be extended up to three years.
- Highway has a composting program where citizens can bring their leaves, clippings, hedge trimmings, etc. Town does not send yard waste drop offs through its chipper due to concerns over potential damage caused by foreign objects.
- Highway does not deal with fertilization of playing fields or other public lands. The Natural Resources Department performs any fertilization work.
- Sand & Salt are mixed in a 5 sand to 1 salt mixture
  - A 60' X 80' covered building (shed) exists for unmixed salt
  - 5:1 sand to salt is stored within another structure
  - Drains at DPW yard drain to a wetland outlet near Conant School
  - Drain overflow goes to 10,000-gal storage tank, drained by septic hauler (Wind River Environmental) whenever necessary. Tank has a high level alarm.
- Transfer station will have a tight tank. Town is working with DEP on this issue.
- Maintenance garage tanks drain to oil/water separator
  - UST have leak detection and key systems
  - UST tank auto-test on 1st Sunday of every month
  - All above ground tanks and barrels are contained within spill control pallet
- Drainage problem areas noted:
  - Corner of Quarry Road and Route 27 (hillside drainage across road)
  - Spencer Road/Prospect Street Area
  - Arlington Street/West Acton Center
  - Stowe Road
- Generally concerned about staffing for any future drainage programs

Department: Natural Resources
Representative: Tom Tidman, Natural Resources Director

- By-Law: No pesticide use within 40' of a wetland or other water body
- Largest "problem areas" with standing water are those areas near beaver impoundments. Fast growing beaver populations are responsible for 20+ impoundments across town (currently) with the promise of more in the near future.
- Natural Resources is not currently involved in any sort of stream maintenance.
- Sources of potential contamination to Nashoba Brook are the construction companies near or on Wetherbee Street. Contamination potential exists due to junk material, automobiles, and other machinery left uncovered close to the brook.
- Fertilization and Irrigation Control
  - No control over fertilization habits of citizens (residential subdivisions)
  - Fields tend to be fertilized more than in the past due to demands by athletic entities.
  - Fertilization records for last year are very good. Kept by the recreation department. These will be supplied to W & C soon.
  - Swimming pond (NARA) fields are under-fertilized due to concerns over nutrient loading to swimming pond.
  - All irrigation water comes from deep bedrock wells on-site. No controls exist for shutoff due to rain. Rain-detection devices are being considered.
  - NARA site has 6.5 acres of auto irrigation. Other areas of automatic irrigation are: 3 acres at 2A-27, and 2 acres on Concord Road, with auto irrigation of the schools planned.
- Currently considering having additional "Turf-Maintenance" training for staff members. Has 4 fulltime employees and one crew leader. All are licensed as pesticide applicators, which is a job requirement. Chris Noble, graduate of U-Mass turf management course, coordinates the fertilizer program.
- Drainage problem areas noted:
  - Cowdrey Lane
  - Elementary School
  - Roche Brothers
  - Ice House Road
  - 2A - Acorn Park
- General drainage concerns:
  - Approximately 20 beaver activity areas
  - Stream management (clearing etc.) is partially conducted along shorelines by stream teams but there is no program of clearing of stream channels.
  - No residential stormwater controls.

Department: Engineering
Representative: David Abbt, Engineering Administrator

- The stormwater related rules and regulations followed by Engineering are contained within the Zoning By-Laws and the Subdivision Rules and Regulations, both of which have been obtained by W & C.
- Building/Development review is coordinated between several departments
  - Planning board reviews all plans for subdivisions
  - Building department reviews all commercial plans
  - Conservation/Natural Resources department reviews if there are potential impacts to wetlands or river ways
- Around 1980, rule was passed that any new commercial or residential development required detention basins to treat 1" stormwater falling on any impervious surface (street/sidewalks for residential)
  - Detention basins sized to 1" run-off volume, have a clay liner, no outlet
  - Basins generally contain cattails and large amounts of pollywogs
  - Typically there is a splitter box that directs "initial flow" to detention pond and excess flow to outlet
  - There is no need for maintenance since the intent is to "naturalize" the basin.
- Construction activities – erosion control plans typically taken from Stormwater Management Handbook
  - Steep slope construction typically causes the biggest erosion control concern
  - Erosion and sediment control plans required from new developments
- Engineering department does final inspection of all street/community development plans prior to acceptance.
  - Engineering department provides field verification of all storm drain systems.
  - No O&M regulations for private subdivisions or commercial property.
  - Subdivision as-builts are kept on file in Engineering
- Detention basins are shown on site plans, but are not mapped on a town-wide map.
- One concern of Engineering is the amount of letter writing and legwork involved in getting commercial (private) developments to maintain their stormwater collection, treatment, or conveyance systems. Difficulty exists with regulating the maintenance of these private systems
  - Commercial establishments have special permits that must be renewed if the owner ever wants to modify the site.
  - Town asks owners to fix any drainage problems. Failure to comply could jeopardize the special permit.
- Currently, no major storm drain improvement programs are in place
  - Problems exist with old "small" pipes clogging or being undersized
  - Some outfalls merely drain 2 catch basins
  - Aluminum pipes seem to be "dissolving", steel pipes are rusting
  - System has many old bends and non-desirable flow directions
  - Many drains were constructed during the WPA projects of the 1930's

Department: Building
Representative: Garry Rhodes, Building Commissioner

- Refer to Zoning By-Laws and Subdivision Rules and Regulations for standard setbacks
- Zoning does not have standard set-backs from water; Natural Resources Department regulates this. Zoning setbacks are from property lines only.
- Zoning Regulations tend to consider groundwater before they consider surface water or wetlands.
- Zone 4 is least restrictive, Zones 1-3 must treat first 1" impervious through detention.
- Ground water regulations:
    - Foundation must be waterproof
    - Foundation drains are routed to wetlands, drainage line, etc. Need a positive removal of water (Gravity to light or pump out.)
    - There is no regulation of the discharge if it is on private property. Public drain connection requires a street opening permit.
    - Permit from Engineering and Natural Resources for street opening and water discharge respectively.
- Complexity of regulations decreases ability to enforce stormwater components. Common sense and "real-world" language would help general understanding of regulations.
- Department would like a way to appeal to a higher board with stormwater related issues
    - Each Town department is charged with looking at a specific issues that may at times conflict with other departments' concerns. All departments are independent authorities, which can be at cross-purposes.
    - When a private entity is not maintaining their stormwater management system, it would be good to have a specific board that the Town can turn to for assistance and enforcement.
- Staffing to regulate and enforce any future stormwater regulations is a concern.

Department: Board of Health
Representative: Doug Halley, Board of Health Director

- Water District controls water use regulations and therefore controls sprinkler regulations
- Woodard & Curran Inc. produced septic system management plan for the Town
- No pooper-scooper law in place
- Composting is through DPW (Highway)
- Yard burning regulations are in place
- Town needs a strategic plan regarding water resources, including stormwater
- Use stormwater to recharge groundwater and return to natural flow.
- Tracing coliform data at several stream locations. Intent is to correlate rainfall versus coliform to determine impact of point sources versus nonpoint sources.

MEMORANDUM

TO: Department of Public Works/Highway

FROM: David Senus, Woodard & Curran Inc.

DATE: December 13, 2001

RE: Acton Town Department Questionnaire

Woodard & Curran Inc. along with the Massachusetts Department of Environmental Protection (DEP) is working with the Town of Acton to develop a non-point source phosphorus reduction program that will address stormwater issues within the Town. One of the tasks set forth for this program by the DEP is to communicate with Town departments about current procedures related to stormwater runoff. The purpose of this survey/questionnaire is to determine the current state of awareness within the Town departments related to stormwater management issues along with determining what stormwater quality control measures are currently in-place. Information gathered in this survey will help to develop Best Management Practices (BMPs) for each department, which in turn will lead to better stormwater quality within the Town.

Please fill in (to the best of your ability) the following department-specific questions and please provide copies of any regulations or documents requested below. If there are additional stormwater quality control measures in-place that are not requested, please feel free to include those measures. For questions or comments, please contact Bob Rafferty {(978) 657-0555} or David Senus {(781) 251-0200} at Woodard & Curran.

Drainage Maintenance

Is there a drainage structure maintenance plan in place? If so, could you provide the following:

- A schedule of maintenance?
- Mapped locations of the maintained drainage structures?
- Any specific information on access problems (are there easements in place)?

- Information on how these structures are cleaned (what equipment: bucket or vacuum truck)?

- How and where is waste disposed?

Street-sweeping

Is there a street sweeping schedule? If so, could you provide a copy of this schedule?

What type of street-sweeper(s)?

- Mechanical
- Regenerative Air
- Vacuum
- Or Tandem Sweeping (mechanical followed by a vacuum).

Other Measures

Does the Town recycle any yard waste?

Does the Town add fertilizer to ball fields, parks or other public lands? If so, how often and how?

Are there automatic sprinklers on public land?

- If so, is there a specific watering program?

What are the storage practices for sand and deicing material, fertilizer/pesticides, etc.?

Is there a preventive maintenance program in place – oil changes, storage, garage maintenance etc.? Are the maintenance areas under roofs? How and where are town trucks and equipment washed?

Could you list several major stormwater problem areas?

What specific concerns related to drainage or stormwater you would like to see addressed?

Are there regulations or guidance materials on:

- Dust control?
- Spill control?
- Record keeping?
- Employee Training (Stormwater related issues)?

WOODARD & CURRAN
Engineering • Science • Operations

12/13/01

MEMORANDUM

TO: Natural Resources/Conservation Department

FROM: David Senus, Woodard & Curran Inc.

DATE: December 13, 2001

RE: Acton Town Department Questionnaire

Woodard & Curran Inc. along with the Massachusetts Department of Environmental Protection (DEP) is working with the Town of Acton to develop a non-point source phosphorus reduction program that will address stormwater issues within the Town. One of the tasks set forth for this program by the DEP is to communicate with Town departments about current procedures related to stormwater runoff. The purpose of this survey/questionnaire is to determine the current state of awareness within the Town departments related to stormwater management issues along with determining what stormwater quality control measures are currently in-place. Information gathered in this survey will help to develop Best Management Practices (BMPs) for each department, which in turn will lead to better stormwater quality within the Town.

Please fill in (to the best of your ability) the following department-specific questions and please provide copies of any regulations or documents requested below. If there are additional stormwater quality control measures in-place that are not requested, please feel free to include those measures. For questions or comments, please contact Bob Rafferty {(978) 657-0555} or David Senus {(781) 251-0200} at Woodard & Curran.

Conservation Control Measures

Are the Town by-laws more stringent than the state Wetlands Protection Act & Rivers Protection Act? If so, could you please provide a copy?

Could you list several major stormwater problem areas?

What specific concerns related to drainage or stormwater you would like to see addressed?

Are there regulations or guidance materials on:

- o Dust control?
- o Spill control?
- o Record keeping?
- o Employee Training (Stormwater related issues)?

WOODARD & CURRAN
Engineering • Science • Operations

12/13/01

MEMORANDUM

TO: Engineering Department

FROM: David Senus, Woodard & Curran Inc.

DATE: December 13, 2001

RE: Acton Town Department Questionnaire

Woodard & Curran Inc. along with the Massachusetts Department of Environmental Protection (DEP) is working with the Town of Acton to develop a non-point source phosphorus reduction program that will address stormwater issues within the Town. One of the tasks set forth for this program by the DEP is to communicate with Town departments about current procedures related to stormwater runoff. The purpose of this survey/questionnaire is to determine the current state of awareness within the Town departments related to stormwater management issues along with determining what stormwater quality control measures are currently in-place. Information gathered in this survey will help to develop Best Management Practices (BMPs) for each department, which in turn will lead to better stormwater quality within the Town.

Please fill in (to the best of your ability) the following department-specific questions and please provide copies of any regulations or documents requested below. If there are additional stormwater quality control measures in-place that are not requested, please feel free to include those measures. For questions or comments, please contact Bob Rafferty {(978) 657-0555} or David Senus {(781) 251-0200} at Woodard & Curran.

Strom-Drain Design

Could you provide a copy of the design standards for:
- o Storm drains?
- o Streets (crown, street drainage structures, etc…)?

When does engineering see and review the plans for developments? What are the procedures for review and permitting?

Are there ordinances or bylaws for stormwater control during and after construction? If so, can you provide a copy?

Are there good examples of drainage and stormwater control that can be examples for future projects?

Are there ongoing drainage plans?

Could you list several major stormwater problem areas?

What specific concerns related to drainage or stormwater you would like to see addressed?

Are there regulations or guidance materials on:

- o Dust control?
- o Spill control?
- o Record keeping?
- o Employee Training (Stormwater related issues)?

WOODARD & CURRAN
Engineering • Science • Operations

12/13/01

MEMORANDUM

TO: Zoning Department

FROM: David Senus, Woodard & Curran Inc.

DATE: December 13, 2001

RE: Acton Town Department Questionnaire

Woodard & Curran Inc. along with the Massachusetts Department of Environmental Protection (DEP) is working with the Town of Acton to develop a non-point source phosphorus reduction program that will address stormwater issues within the Town. One of the tasks set forth for this program by the DEP is to communicate with Town departments about current procedures related to stormwater runoff. The purpose of this survey/questionnaire is to determine the current state of awareness within the Town departments related to stormwater management issues along with determining what stormwater quality control measures are currently in-place. Information gathered in this survey will help to develop Best Management Practices (BMPs) for each department, which in turn will lead to better stormwater quality within the Town.

Please fill in (to the best of your ability) the following department-specific questions and please provide copies of any regulations or documents requested below. If there are additional stormwater quality control measures in-place that are not requested, please feel free to include those measures. For questions or comments, please contact Bob Rafferty {(978) 657-0555} or David Senus {(781) 251-0200} at Woodard & Curran.

Zoning Issues

What are standard setbacks?

Are there any special setbacks for water resources? (Cluster vs. large lots)

Are there regulations or guidance materials on:

- Dust control?
- Spill control?
- Record keeping?
- Employee Training (Stormwater related issues)?

Could you list several major stormwater problem areas?

What specific concerns related to drainage or stormwater you would like to see addressed?

MEMORANDUM

TO: Planning Department

FROM: David Senus, Woodard & Curran Inc.

DATE: December 13, 2001

RE: Acton Town Department Questionnaire

Woodard & Curran Inc. along with the Massachusetts Department of Environmental Protection (DEP) is working with the Town of Acton to develop a non-point source phosphorus reduction program that will address stormwater issues within the Town. One of the tasks set forth for this program by the DEP is to communicate with Town departments about current procedures related to stormwater runoff. The purpose of this survey/questionnaire is to determine the current state of awareness within the Town departments related to stormwater management issues along with determining what stormwater quality control measures are currently in-place. Information gathered in this survey will help to develop Best Management Practices (BMPs) for each department, which in turn will lead to better stormwater quality within the Town.

Please fill in (to the best of your ability) the following department-specific questions and please provide copies of any regulations or documents requested below. If there are additional stormwater quality control measures in-place that are not requested, please feel free to include those measures. For questions or comments, please contact Bob Rafferty {(978) 657-0555} or David Senus {(781) 251-0200} at Woodard & Curran.

Potential Planning Related Stormwater Issues

We are interested in the Development Review Process. Specifically, how the Development Review Process addresses stormwater runoff control.

WOODARD & CURRAN
Engineering • Science • Operations

12/13/01

Please elaborate on and provide any guidelines, standards, regulations or by-laws related to construction runoff control, general erosion control, drainage, road design (min widths etc), cluster development vs. large lot zoning, etc…

Are there good examples of drainage or stormwater control that can be used as good examples for other projects?

Could you list several major stormwater problem areas?

What specific concerns related to drainage or stormwater you would like to see addressed?

Are there regulations or guidance materials on:

- Dust control?
- Spill control?
- Record keeping?
- Employee Training (Stormwater Related issues)?

MEMORANDUM

TO: Board of Health

FROM: David Senus, Woodard & Curran Inc.

DATE: December 13, 2001

RE: Acton Town Department Questionnaire

Woodard & Curran Inc. along with the Massachusetts Department of Environmental Protection (DEP) is working with the Town of Acton to develop a non-point source phosphorus reduction program that will address stormwater issues within the Town. One of the tasks set forth for this program by the DEP is to communicate with Town departments about current procedures related to stormwater runoff. The purpose of this survey/questionnaire is to determine the current state of awareness within the Town departments related to stormwater management issues along with determining what stormwater quality control measures are currently in-place. Information gathered in this survey will help to develop Best Management Practices (BMPs) for each department, which in turn will lead to better stormwater quality within the Town.

Please fill in (to the best of your ability) the following department-specific questions and please provide copies of any regulations or documents requested below. If there are additional stormwater quality control measures in-place that are not requested, please feel free to include those measures. For questions or comments, please contact Bob Rafferty {(978) 657-0555} or David Senus {(781) 251-0200} at Woodard & Curran.

BOH Regulations

In addition to addressing whether the following exist, could you provide a copy of any of the following regulations?

- o Are there automatic sprinkler regulations?

- o Is there a septic system / onsite sewage disposal management plan in place?

- Are there yard or pet waste controls?

- Is there a composting program?

- Is there a town-wide yard waste collection and composting program?

- Are there regulations or guidance materials on:
  - Dust control?
  - Spill control?
  - Record keeping?
  - Employee Training (Stormwater Related issues)?

Could you list several major stormwater problem areas?

What specific concerns related to drainage or stormwater you would like to see addressed?

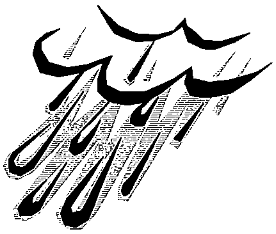
Public Education

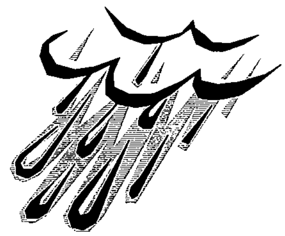
- Is there public education material on hand regarding fertilizer usage or other stormwater related issues?

APPENDIX C: EDUCATION AND OUTREACH MATERIAL

This project has been financed with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under an s.319 competitive grant. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Town of Acton





Massachusetts

Stormwater Awareness Survey

The wet area located on the hill between the beach and the bandstand is a specially constructed wetland. It is built to remove pollution, namely excess phosphorus, from stormwater drainage before it reaches the swimming pond. Please help us to create educational material for this project by answering the following questions. Thank you!

BACKGROUND

Please check (✓) your age group.

____Less than 18
____18 - 25
____25 - 45
____45 - 65
____over 65

How many years have you lived or worked in Acton?

____0 – 2
____3 – 6
____7 – 11
____Over 12
____I don't live in Acton

How often do you visit NARA Park each year?

____First time
____0 - 5
____5 - 10
____10 – 20
____Over 20

Please check (✓) your primary news source?

____Television
____Internet
____Radio
____Newspaper
____News Magazine
____Other

OPINION

1) On average, how would you rate the water quality of North Acton Recreation Area (NARA) Park swimming pond?

____Excellent
____Good
____Fair
____Poor

2) *My neighborhood* contributes to the water quality in Acton's streams and ponds:

____Significantly
____Some impact
____Minimal impact
____No impact

3) *I* contribute to the water quality in Acton's streams and ponds:

____Significantly
____Some impact
____Minimal impact
____No impact

4) Protecting Acton's streams and ponds is:

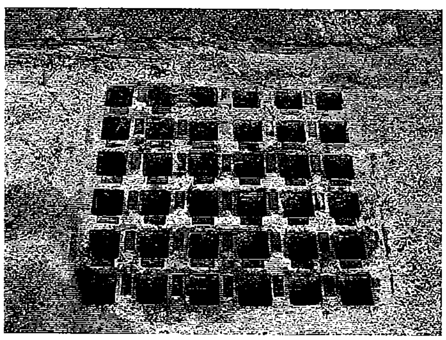
____ Very important
____ Important
____ Necessary
____ Not important

STORMWATER IQ

5) How will the wetlands replication constructed in the NARA Park help Acton's streams and ponds?
____It will reduce phosphorus pollution of the NARA swimming pond.
____It will provide a wildlife corridor for animals to cross the NARA Park.
____It will reduce phosphorus pollution of the Assabet River.
____All of the above.

6) What are the effects of too much phosphorus on streams and ponds?
____Very large fish
____Decreased plant growth
____High oxygen levels
____None of the above

7a) Where does water go from here?



____The new wastewater treatment plant
____Nashoba Brook (or another local stream)
____Stays underground
____Don't know

7b) What should go in here?
____Carwash water
____Oil/paint
____Pet waste
____Water only
____Sewage

8) What are signs of eutrophication in a lake? (Check all that apply)
____Dead fish
____Bad smell
____Lots of ducks and geese
____No swimming allowed
____Algae on the water surface

9) Runoff is:
____Rain and snow melt flowing over land
____Sewer flow
____Animals abandoning their habitat
____Don't know

10) "Non-point source" pollution comes from: (Check all that apply)
____Stormwater running directly off roads, parking lots, grass, etc.
____Landfill site leaching
____Leaking septic systems
____Waste water treatment plants

11) To what extent would you be willing to support efforts to improve Acton's surface waters through storm water management programs? (*In no way does this question obligate residents to pay any money toward these efforts. It is simply a way to measure support for water quality improvement programs.)*

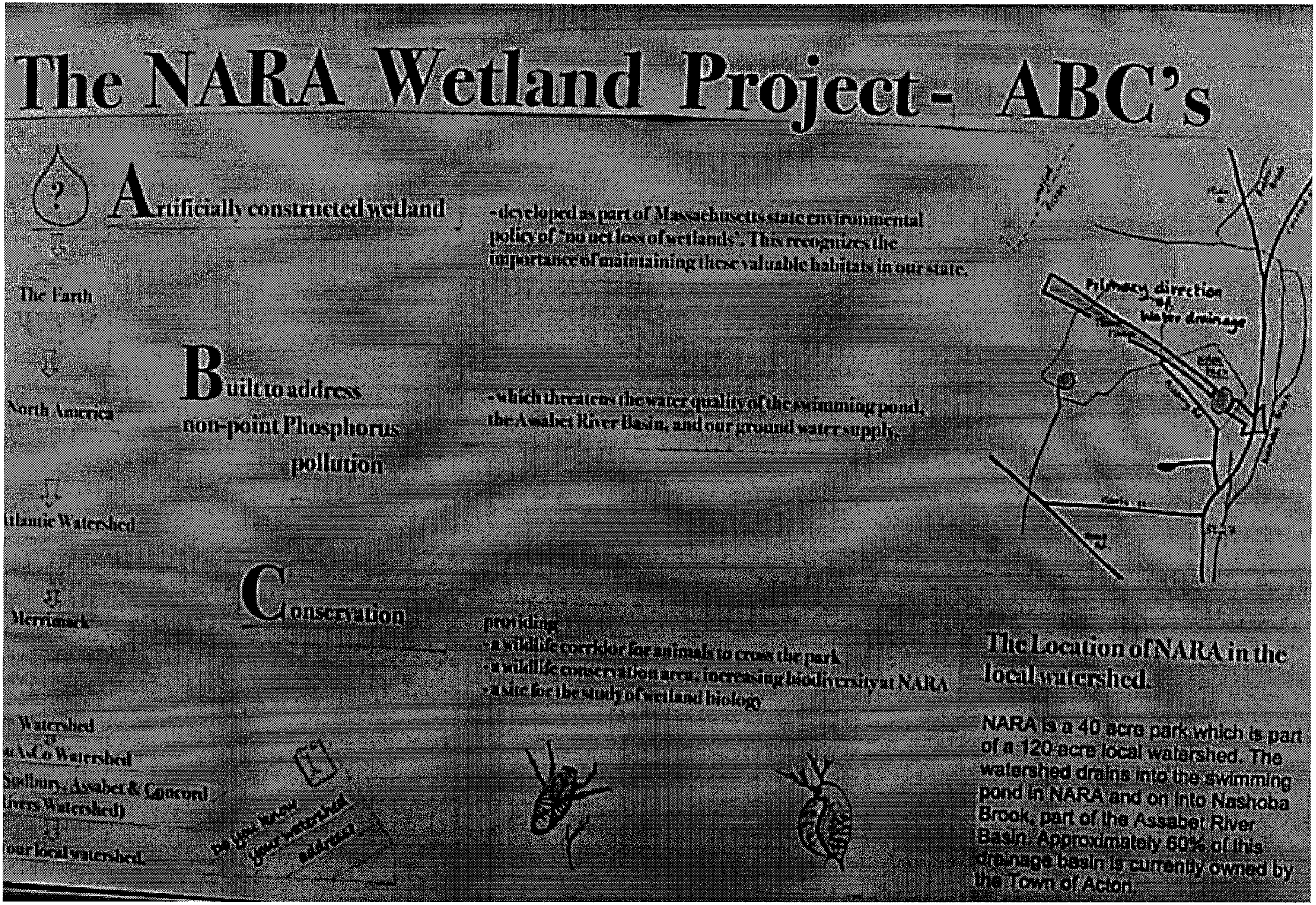
Increase taxes:
____ $75 + per year per household
____ $50-$75 per year per household
____ $25-$49 per year per household
____ $1-$24 per year per household
____ $0 - I would not like to see these programs funded through tax dollars

12) Would you like to learn more about protecting local waterways?

____Yes ____No

Please write your name and address here if you would like to participate in the follow-up survey or receive more information.

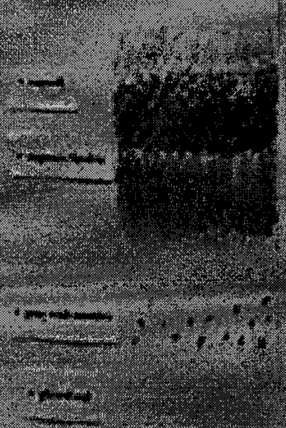
____
____
____
____
____
____
____
____
____


The NARA Wetland Project - ABC's
Artificially constructed wetland
- developed as part of Massachusetts state environmental policy of 'no net loss of wetlands'. This recognizes the importance of maintaining these valuable habitats in our state.
Built to address non-point Phosphorus pollution
- which threatens the water quality of the swimming pond, the Assabet River Basin, and our ground water supply.
Conservation
providing
- a wildlife corridor for animals to cross the park
- a wildlife conservation area, increasing biodiversity at NARA
- a site for the study of wetland biology
The Earth
North America
Atlantic Watershed
Merrimack
Watershed
SuAsCo Watershed
(Sudbury, Assabet & Concord Rivers Watershed)
Your local watershed.
Do you know your watershed address?
Primary direction of water drainage
The Location of NARA in the local watershed.
NARA is a 40 acre park which is part of a 120 acre local watershed. The watershed drains into the swimming pond in NARA and on into Nashoba Brook, part of the Assabet River Basin. Approximately 60% of this drainage basin is currently owned by the Town of Acton.

What is a wetland?

...a swampland; marsh; bog; fen; pothole; mire. Scientists define a wetland as a diverse collection of areas where the presence of water for extended periods exerts a controlling influence on the soil characteristics. These soils support specialized plant and animal communities that are dependent on wetlands for their food, shelter, and reproduction. As specialists, they are sensitive to environmental changes. The diversity of wetland plants and animals increases the value of the entire environment.

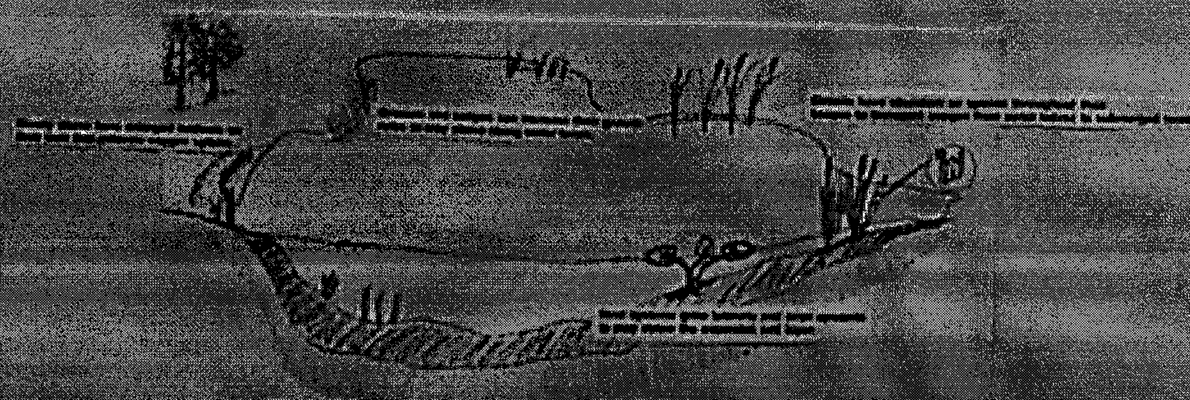
What are hydric soils?

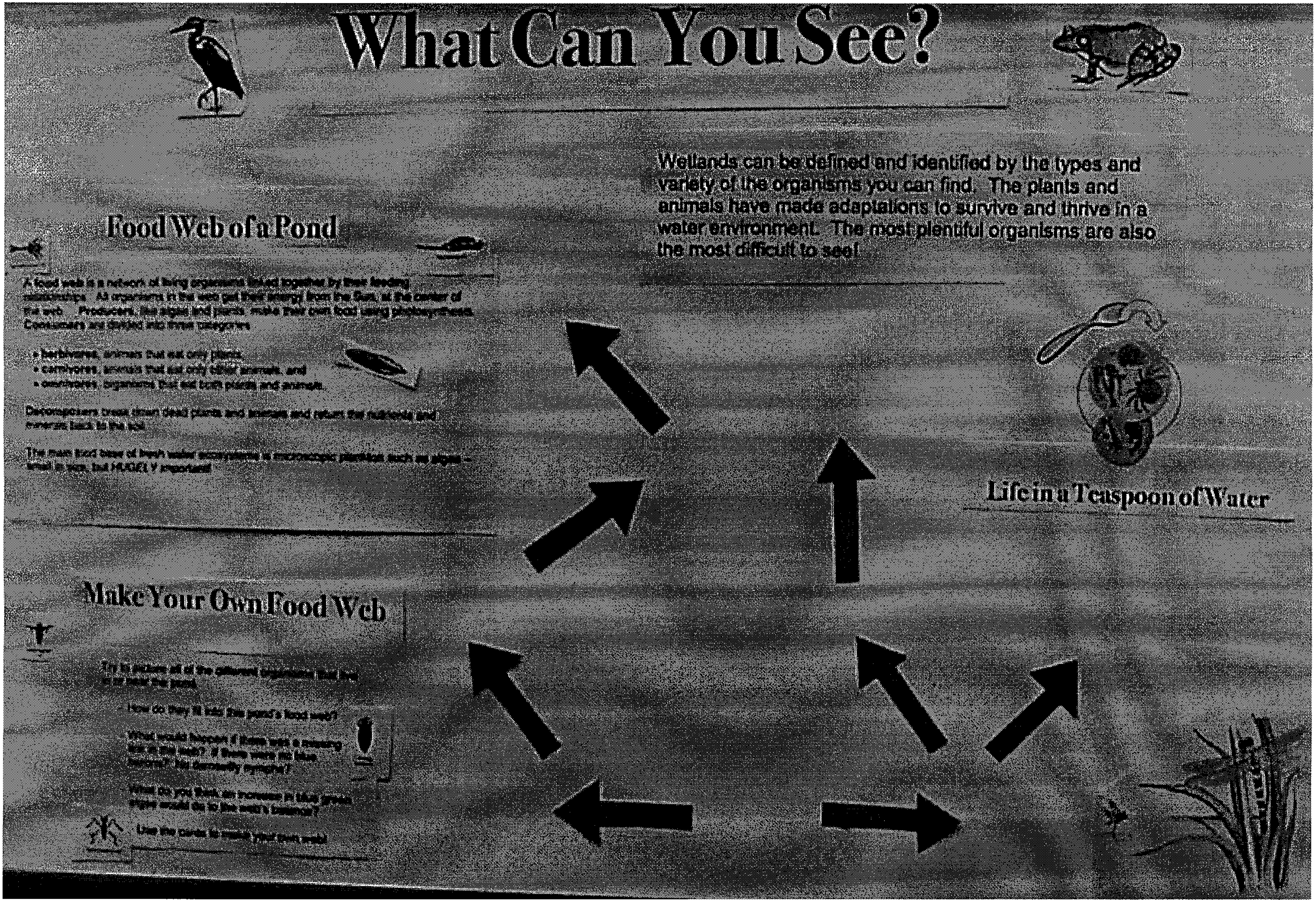


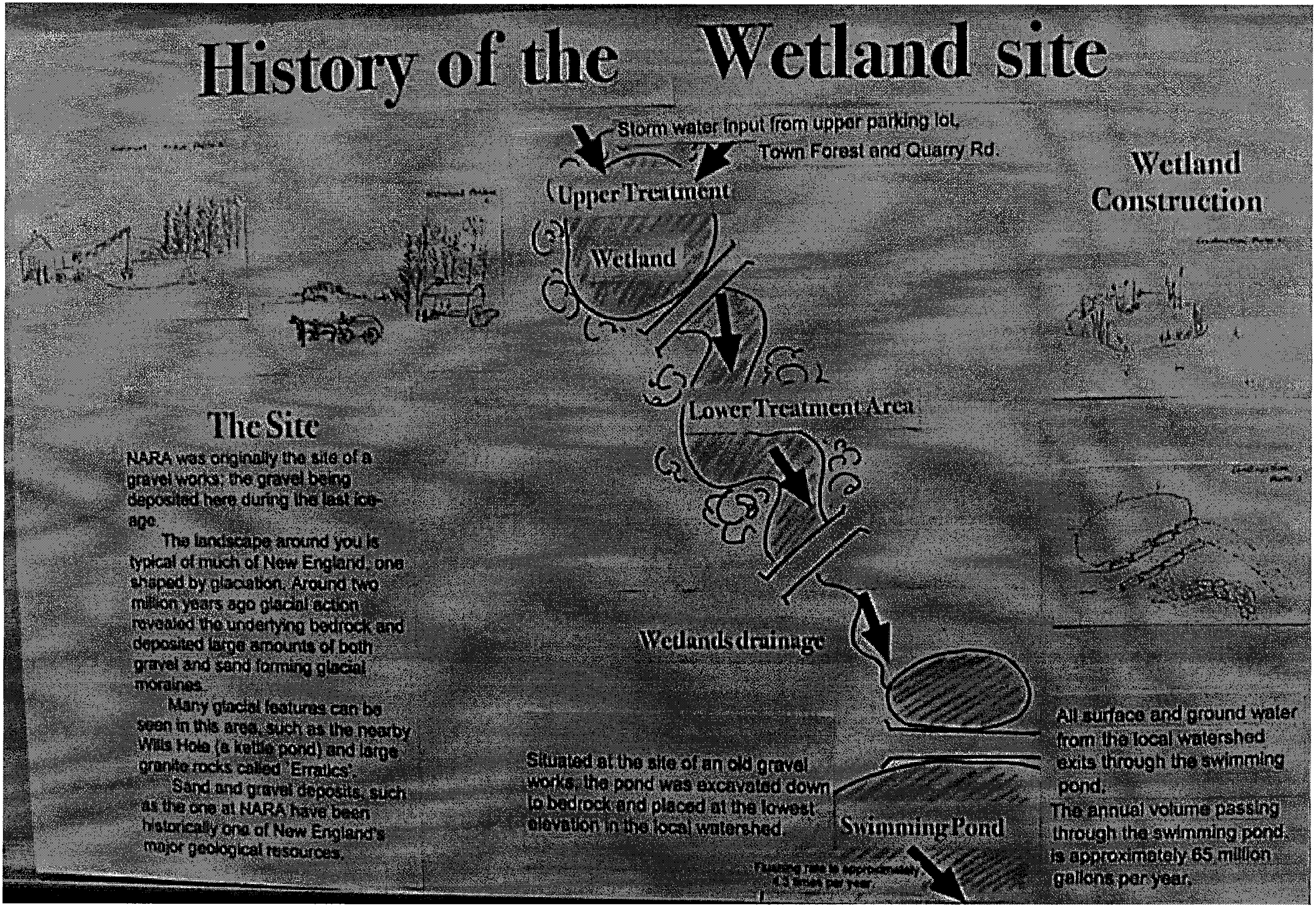
- Hydric soils form when poorly drained soils remain water-logged at or near the surface in winter.
- Often a dark brown to black enriched organic layer develops.
- Prolonged saturation depletes the oxygen in the soil.
- These anaerobic conditions inhibit the breakdown of organic materials.
- Anaerobic microbes create a "rotten egg" smell from sulphur metabolism.
- Hydric soils feel wet and ooze through your fingers!
- Hydric soils support wetland plants.

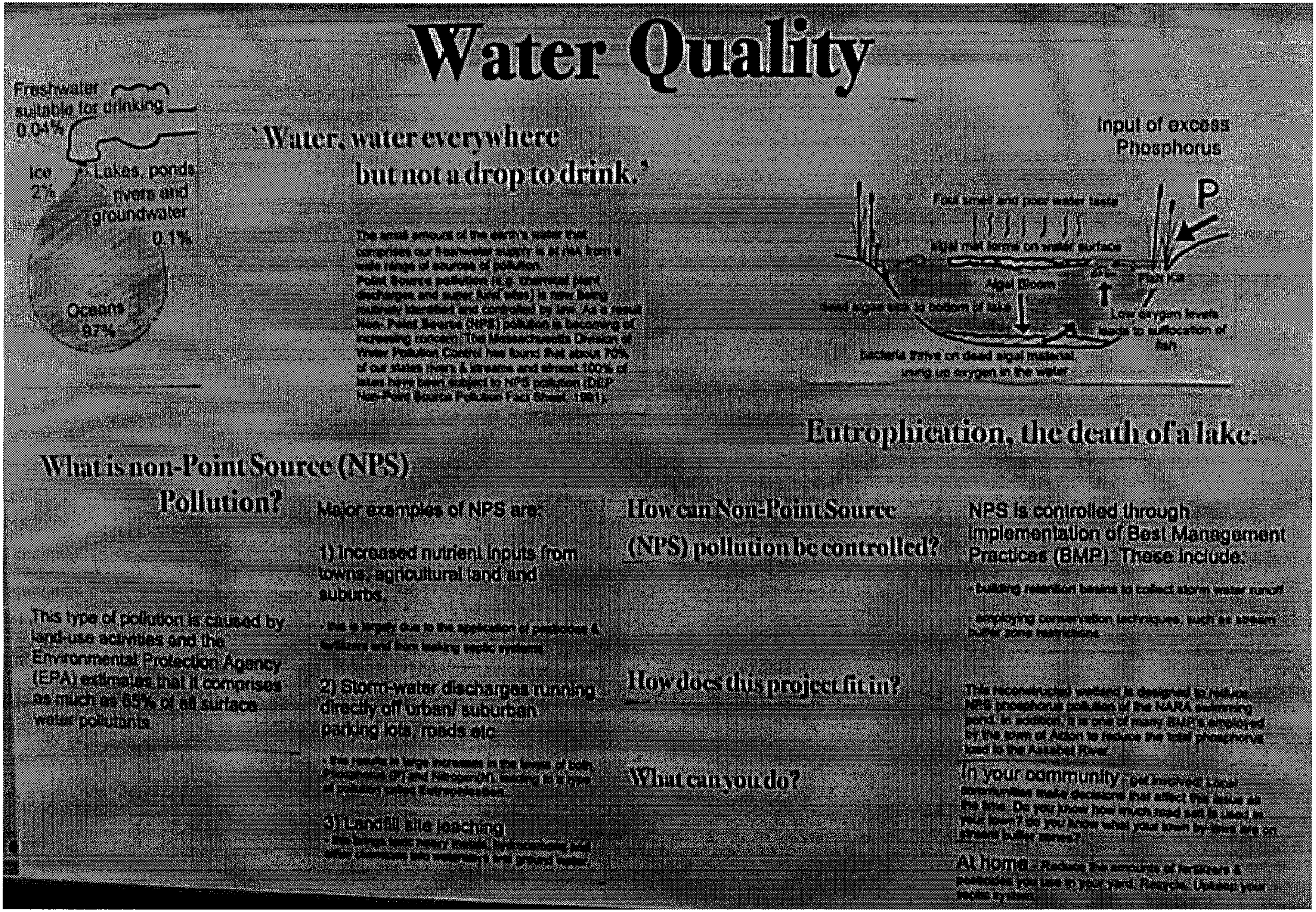
How do plants survive in water-logged soils?

Plants that live in wetland areas are adapted morphologically and biochemically to water-logged soils. They can tolerate the low oxygen concentrations found in hydric soils. Many species have special features to get oxygen to their roots and other tissues that are submerged.




What Can You See?
Wetlands can be defined and identified by the types and variety of the organisms you can find. The plants and animals have made adaptations to survive and thrive in a water environment. The most plentiful organisms are also the most difficult to see!
Food Web of a Pond
Life in a Teaspoon of Water
Make Your Own Food Web


History of the Wetland site
Storm water input from upper parking lot, Town Forest and Quarry Rd.
Upper Treatment
Wetland
Lower Treatment Area
Wetlands drainage
Swimming Pond
Wetland Construction
The Site
NARA was originally the site of a gravel works, the gravel being deposited here during the last ice-age.
The landscape around you is typical of much of New England, one shaped by glaciation. Around two million years ago glacial action revealed the underlying bedrock and deposited large amounts of both gravel and sand forming glacial moraines.
Many glacial features can be seen in this area, such as the nearby Wills Hole (a kettle pond) and large granite rocks called 'Erratics'.
Sand and gravel deposits, such as the one at NARA have been historically one of New England's major geological resources.
Situated at the site of an old gravel works, the pond was excavated down to bedrock and placed at the lowest elevation in the local watershed.
All surface and ground water from the local watershed exits through the swimming pond.
The annual volume passing through the swimming pond is approximately 65 million gallons per year.



Water Quality
Freshwater suitable for drinking 0.04%
Ice 2%
Lakes, ponds rivers and groundwater 0.1%
Oceans 97%
'Water, water everywhere but not a drop to drink.'
Input of excess Phosphorus
P
Algal Bloom
Fish Kill
Eutrophication, the death of a lake.
What is non-Point Source (NPS) Pollution?
This type of pollution is caused by land-use activities and the Environmental Protection Agency (EPA) estimates that it comprises as much as 65% of all surface water pollutants.
Major examples of NPS are:
1) Increased nutrient inputs from towns, agricultural land and suburbs.
2) Storm-water discharges running directly off urban/ suburban parking lots, roads etc.
3) Landfill site leaching
How can Non-Point Source (NPS) pollution be controlled?
NPS is controlled through implementation of Best Management Practices (BMP). These include:
How does this project fit in?
What can you do?
In your community
At home

POND-DIPPING
(Gr. 6-8)

Goals: To introduce the campers to a freshwater habitat and the animals that live in it. To expose them to some of the great diversity of freshwater life and to encourage them to consider what adaptations these animals might have to their environment.

Materials: Selection of nets and poles with sieves attached. Buckets or other containers for captured pond life, trays to examine finds, magnifiers, clipboards, 'Aquatic Creature Cards', notebooks, writing/drawing materials, rulers, identification/guide books. Previously caught animals will be available.

Activity 1: Introduction

- Assemble campers on the beach and talk about the pond at NARA. (*This is a man- made pond excavated from an old sandpit. It was made specifically for swimming and boating. In the few years since its construction a variety of wildlife have made their homes here. Ask the campers what they have seen already in the pond: maybe fish, frogs and crayfish. Mention also flying animals that use the pond: e.g. Dragonflies & the Great Blue Heron. Point out that ponds are important sources of water for wildlife such as raccoons, white-tail deer etc. They also provide food for terrestrial animals; herons catch fish; raccoons eat crayfish; and swallows catch the variety of flies hatching out from their aquatic larval stages. Ponds are also important breeding grounds for a variety of amphibians such as frogs and home to reptiles such as turtles and water snakes.*
- *If no one has mentioned any of the smaller animals that live in ponds and lakes, such as insect larvae and aquatic beetles, point out that there are many of these creatures and that they often go unnoticed. These are important components of the food webs associated with freshwater ponds, providing food for larger more conspicuous animals. It is these small creatures that the campers are mainly going to find today.)*

-

-

- Ask if anyone knows what makes a pond and why <u>this</u> is a pond not a lake?

- (Both *ponds & lakes are bodies of freshwater. Ponds are shallower and because of this, light can reach down throughout the depth allowing plants to grow from shore to shore. Lakes are deeper and all have a region in the center where insufficient light reaches the bottom to allow rooted green plants to grow.*) Explain that today they are going to walk around the pond looking at some of its features. Then stopping at a suitable spot, they will look for some of the creatures that make their homes here.

Activity 2: Pond walk

Follow the route marked on your map and stop at the three marked places. At each spot encourage the campers to look both at the vegetation around the pond and for any signs of animals.

Site.1 is a slight detour from the main pond to look up at a project underway at NARA, the reconstruction of a wetland habitat. Explain that Town is developing this site for several reasons. First, to restore wetland habitat lost when NARA was built and because these unique habitats are under pressure elsewhere in our town due to building. Secondly to provide an easily accessible wetland area to serve as an educational resource for providing information about these habitats. Finally, this is also an experimental site for using wetlands as a natural method of removing phosphates from the swimming pond. Pollution with phosphates is a common problem with lakes used for recreation and passing the lake water through this wetland should allow for phosphate removal that is cost-effective and natural. (*Water will be piped out of the pond and enter the wetland at the top of the wetland region you can see, it will then percolate down the hill, through the wetland and re-enter the lake near the adjacent boardwalk. The effectiveness of this for phosphate removal will be measured over time.*). Get the campers to look at the adjacent 'pond' area. The tall cattails are noticeable emergent vegetation (*green plants growing out of the water)* and animal life often seen here includes Green Frogs in the water and Dragonflies over the pond. Point out that ponds change with time and that growth of emergent vegetation such as these may extend over the whole of the surface creating a marsh.

Site 2 is midway over the board walk. This is a good spot to stop and look over both parts of the main pond. There are some nice emergent plants to see including Yellow Irises and pond lily. Dragonflies should be seen here and often visiting bird species including swallows. Looking into the water some animal life may be seen, maybe small fish such as Sunfish.

Site.3 is on the far side of the pond. Point out the vegetation growing along the pond side. This shore of the pond is commonly visited by Great Blue Heron in the early evening, coming to fish at the pond. People walk past, even with dogs, within feet of these birds without being aware of them.

Site.4 is a small pond area adjacent to the lower parking lot. This is the site for ponding.

Activity 2. Pond-dipping

- Hand out equipment and Creature Cards. Split campers into teams of 2-4, depending on numbers. Each group should have a clipboard and 6 Creature Cards, along with a pencil, ruler, net or pole and some containers. Each team will need to designate a Recorder to fill in the creature cards when they have made a capture. Before starting to look for animals discuss where they might be found. (Suggest they look for animals that live in amongst the plants/ weed, animals that live on or in the substrate (the ponds bottom) and those that live in the open water). REMIND CAMPERS THAT THEY SHOULD TREAT ANY ANIMALS THEY FIND WITH RESPECT AND THAT THEY SHOULD ALSO CAUSE AS LITTLE DAMAGE AS POSSIBLE TO THE HABITAT. *Go dipping!*

- Reassemble and let each team present its findings. Encourage discussion of what creatures they found and where they found them in the pond (*in weed/ on substrate/ in water column).* If a creature is found that no one knows encourage the campers to use the guidebooks to try and identify it. What might these creatures be feeding on? How might they be adapted to life in the pond? Are any of them the young of other animals? (*Tadpoles are the young of Frogs or Salamanders. Many juvenile stages of insects are found in ponds, such as Dragonfly larvae. Do not be too concerned about accurately naming finds, the spirit of this unit is to observe the diversity of life in freshwater habitats and to get some idea of how animals adapt to their environments. There is a whole other world in ponds that most people do not even notice!*)

- If needed use the previously caught animals to add diversity.

- In any remaining time encourage the campers to draw some of their catches in their Nature Journals.

- Hold a `Release Ceremony' and return the creatures to the pond!

POND-DIPPING : CREATURE CARDS

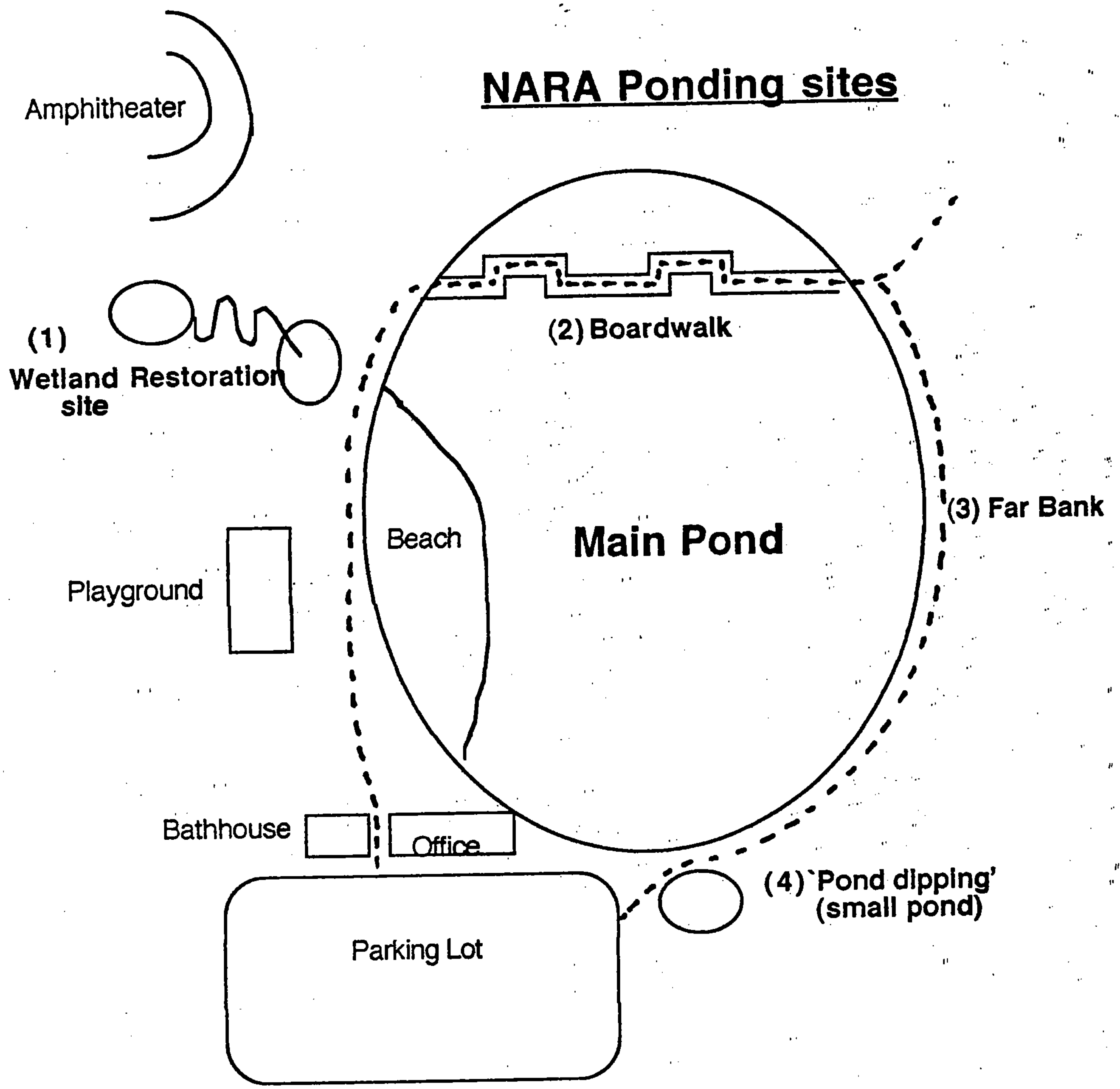
Draw your creature in the space below.

Try to answer the questions below:

1. How big is it?
2. Where did you find it in the pond (in weeds, in the water column or on the bottom)?
3. How does it move around?(does it have legs/ fins?)
4. What is its outer surface like? (scaly/ hard/soft?)
5. Other observations:

6. What creature do you think it is and why?

NARA Ponding sites



APPENDIX D: WETLAND MAPS & FIGURES

Appendix D – Project Photograph 1

This view of constructed wetland looks downstream from the first kiosk location showing the observation/kiosk locations at the right and left of upper pool along the walkway. The walkway traverses weir no. 1 and separates the top two segments of the wetland. The swimming pond is visible at the top right. The semi-circle teaching amphitheater is shown to the left of the walkway on the grassed slope.

Appendix D – Project Photograph 2

This view of constructed wetland is from the top of NARA's large amphitheater. It shows the walkway separating the top two wetland segments at the left of the photograph, with the rock swale from the bedrock well to the right near the shrubs.

Appendix D – Project Photograph 3

This view of the constructed wetland shows the second segment with the walkway traversing weir no. 1 to the right and weir no. 2 to the left. The swimming beach is in the background on the left. The teaching amphitheater is in the foreground.

Appendix D – Project Photograph 4

This view of the constructed wetland shows the third segment below the walking path and weir no. 2, with the swimming pond in the background.

Appendix D – Project Photograph 5

This view of the constructed wetland shows the micro-pool to the left of the walkway. The walkway follows the berm separating the micro-pool from the swimming pond. The wetland outlet is located at the right side of the micro-pool, to the left of the walkway bridge. (This section of the walkway was constructed as part of the swimming pond, outside of the s.319 grant project.)

Appendix D – Project Photograph 6

This view shows the walkway at the teaching amphitheater, looking upstream.

Appendix D – Project Photograph 7

This photograph shows a snakeskin in the second segment of the constructed wetland.

Appendix D – Project Photograph 8

This photograph shows the upper pool from the vicinity of the rock swale. Weir no. 1 is to the left of the photograph.

APPENDIX E: SITE SELECTION REPORT

Personnel Involved:

Authors:
David A. Senus, EIT, W&C
Robert J. Rafferty, P.E., W&C

Project Manager:
Robert J. Rafferty, P.E., W&C

Quality Assurance Officer:
Helen Priola, P.E., W&C

DEP Project Officer:
Brian Duval, DEP

DEP 319 Program Coordinator:
Jane Peirce

EPA Quality Assurance Officer:
Arthur Clark, EPA

EPA 319 Program Coordinator:
Bruce Rosinoff, EPA

Town:
Town of Acton
472 Main Street
Acton, MA 01720

Consultant:
Woodard & Curran Inc.
35 New England Business Center
Suite 180
Andover, MA 01810

Governing Agencies:
Massachusetts Department of Environmental Protection
Bureau of Resource Protection
627 Main Street
Worcester, MA 01608

United States Environmental Protection Agency
60 Westview Street
Lexington, MA 02421

DRAFT REPORT on
WATERSHED TRADING PROGRAM
STRUCTURAL BMP SITE SELECTION

Town of Acton
Nonpoint Source Control Program
Project 00-07/319

WOODARD & CURRAN
Engineering · Science · Operations
980 Washington Street
Suite 325N
Dedham, MA 02026

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICIES

DRAFT REPORT
on
WATERSHED TRADING PROGRAM
STRUCTURAL BMP SITE SELECTION

Town of Acton Nonpoint Source Control Program
Project 00-07/319
Part A – Watershed Trading

1. INTRODUCTION

The Town of Acton (the Town) has implemented a Watershed Trading Program as part of an Environmental Protection Agency (EPA) National Pollution Discharge Elimination System (NPDES) permit to discharge treated wastewater effluent to the Assabet River. The focus of this effort is a reduction in phosphorus loading to the Assabet River. This report deals with a portion of the Watershed Trading Program financed with federal funds from the EPA to the Massachusetts Department of Environmental Protection (MADEP) under an s.319 competitive grant.

According to the EPA grant scope documents, "This project is intended to pilot watershed trading programs that will become increasingly important and common in the coming years as communities strive to meet new NPDES requirements." This report focuses on Task A2, Watershed Trading Program Structural Best Management Practice (BMP) Site Selection. In Section A of Deliverable A2 of the Scope of Services, a draft site selection report must be submitted for approval to the MADEP Project Officer.

This report outlines the site selection process used for determining feasible locations for installing structural BMPs. The sites chosen for baseline monitoring in accordance with the procedures outlined in the Quality Assurance Project Plan (QAPP) (delivered to MADEP with submittal letter dated March 13) are detailed in this report, including the rationale behind choosing the sites and a detailed map of each. Selected outfall locations and pertinent site characteristics that are specific to each outfall are presented.

2. SITE SELECTION PROCESS

2.1 APPROACH

The selection of sites for structural BMPs requires an iterative approach since the site selection is dependent on the types of structural BMPs implementable at each site, and the BMP is dependent upon the site characteristics. The process used to select sites for further monitoring included a preliminary review of potential structural BMPs. Therefore, several rounds of screening and site visits were needed to be confident that each potential site was capable of supporting a structural method of phosphorus reduction.

The Town developed the initial screening criteria to identify sites that may benefit from structural BMPs under this program. Input was received from the Board of Health (BOH), Natural Resources Department and the Engineering Department. Four rounds of screening, each with increasingly refined parameters, were conducted on November 7, 2001, January 9, 2002, January 25, 2002 and March 14, 2002.

Out of the seventeen (17) sites selected for preliminary evaluation, ten (10) sites were selected for more intensive evaluation. Five (5) sites were ultimately selected for sampling and testing. The initial seventeen (17) sites were selected based on the following general criteria:

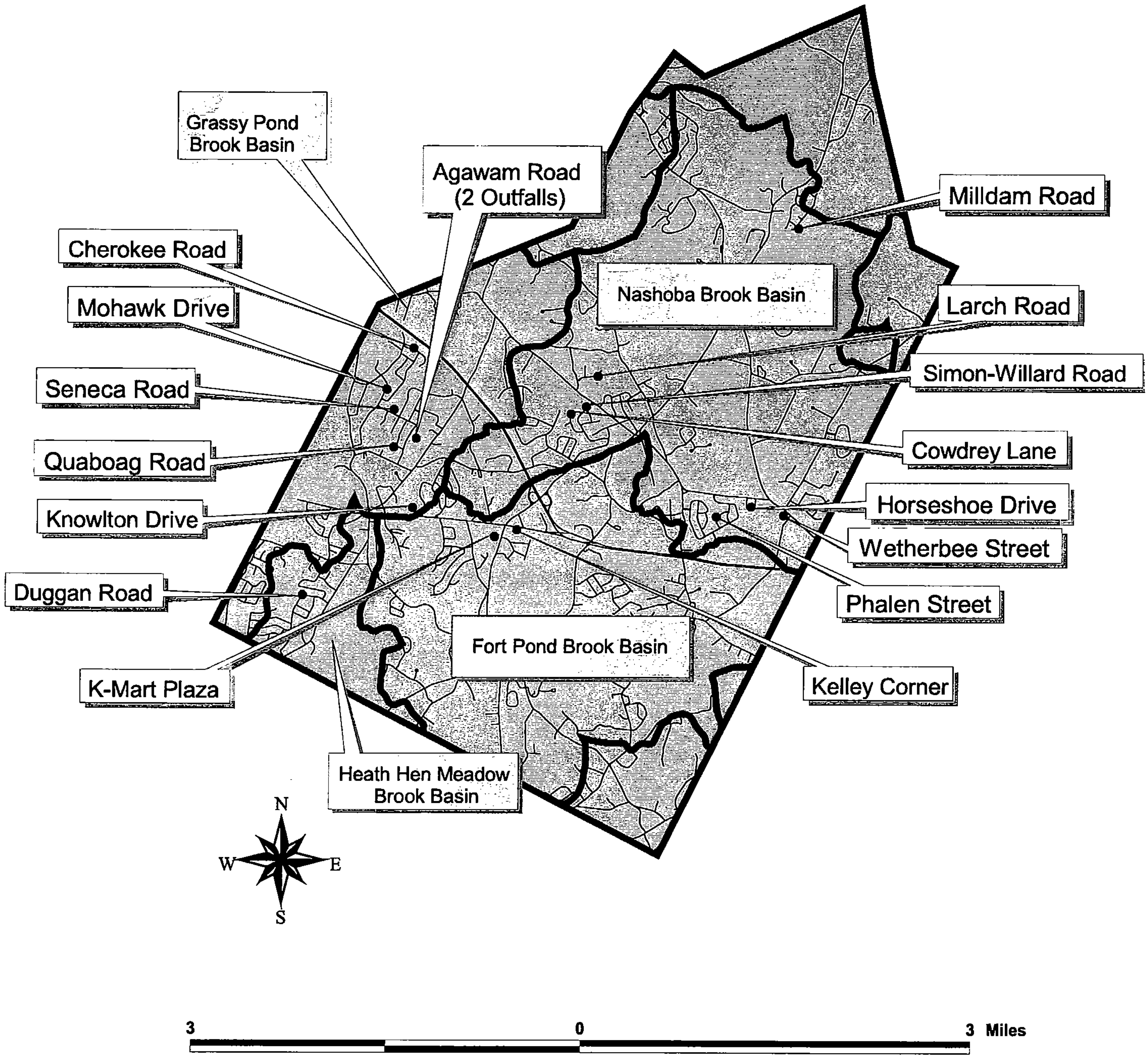
- Available storm drain mapping to define the drainage area;
- Potential for relatively high phosphorus loading at the site due to land uses in the drainage area;
- Potential for public awareness;
- Potential for the continued influence of on site wastewater disposal systems;
- Readily accessible for monitoring (pre and post construction);
- Readily accessible for construction and operation and maintenance of a BMP; and
- Diversity in regard to geographic area, impact to downstream waterways, land use, and size of drainage area.

The locations of the seventeen (17) sites are shown on Figure 2.1.

Evaluating the drainage area and the downstream fate of stormwater was essential for refining the initial list of seventeen (17) outfalls. The study of the Town's drainage maps provided an indication of the total watershed area that contributes stormwater to each outfall. Additionally, the Town's drainage maps provided information on the network of drainage channels, as well as streams and wetlands that collect and transfer stormwater from the outfall locations to the major streams within the Town.

The Town's drainage maps are currently in the process of being digitized. Upon completion of the digitization process, Graphical Information System (GIS) topographic maps can be overlaid to derive the precise drainage area contributing to each BMP site, and subsequent BMP design can be completed. An additional benefit to digitizing the Town's drainage system is the formation of an interactive drainage map within GIS.

Figure 2.1 Initial 17 Outfalls Investigated



2.2 SITE SELECTION MATRIX

The initial seventeen (17) sites were visually inspected and evaluated. A draft Site Selection Matrix (SSM) was developed during this initial round of inspections to focus the evaluation efforts on the most promising ten (10) sites. The draft SSM was provided to the MADEP Project Officer during the development stage.

The SSM was refined with each round of inspections. The final SSM is included as Table 2.1. Methods for developing the site selection matrix were derived from such sources as the Massachusetts Stormwater Policy Handbook (prepared by the MADEP and The Office of Coastal Zone Management), EPA fact sheets on BMP technologies, and EPA and MADEP stormwater management documents. These materials provide valuable information on non-point sources of nutrients, BMP technologies that may be used to lower nutrient concentrations in stormwater, and site characteristics that can be favorable to or complicate BMP applications.

The SSM displays selection criteria ranking for each of the seventeen (17) sites. The selection categories reflect the desirable characteristics for design and construction of a BMP at the site. Each site was ranked based on a number of important site criteria. The matrix uses a ranking of 1 for least favorable and 3 for most favorable.

A multiplier from 0.3 to 1.0 was used to weigh the importance of the criteria. For example, the potential for high phosphorus loading is very important to this study; therefore, it was assigned a multiplier of 1.0. Less important criteria, such as the potential for combining multiple BMP technologies, were assigned a multiplier of 0.3.

In some cases a site was not acceptable, or not feasible, in one particular category for implementing a structural solution. Therefore, a ranking of zero (0) was assigned to these sites for that specific category. A site was removed from further consideration if it received a score of zero for any critical criteria, with critical criteria defined as having a category multiplier of at least 0.8.

Criteria deemed critical to the installation of a structural BMP are:

- Suitable space for a structural BMP (including minimizing any negative environmental impact);
- Capacity for head loss through a structural BMP;
- Potential for infiltration determined through soils types per SCS and visual observation, available land area, and depth to observable water level (the most effective means of reducing phosphorus loads in surface waters);
- Predictable flow determined through ability to delineate drainage area(critical for proper sizing and operation of a structural BMP);
- Potential for high phosphorus loading determined through land use patterns; and
- Downstream influence (measurable and effective reduction in phosphorus).

Table 2.1 BMP Site Selection Matrix

Selection Criteria / Category	Category Multiplier (0.1-1)	Agawam Road (B/W #34 & #36)	Agawam Road (B/W #32 & #34)	Cherokee Road	Cowdrey Lane	Duggan Road	Horseshoe Drive (Pond)	Kelley Corner (Across from Roche Bros.)	K-Mart (NW Corner of Parking Lot)	Knowlton Drive	Larch Road	Milldam Road	Mohawk Drive	(A) Phalen Street (BMP at End-of-Pipe)	(B) Phalen Street (BMP in Road)	Quaboag Road	Seneca Road	Simon-Willard Road	Wetherbee Street
		Potential BMP Sites																	
Suitable Space for Structural BMP	1	3	3	1	1	2	3	2	2	2	3	2	3	2	2	3	3	1	3
Capacity for Headloss	0.8	1	1	1	1	2	3	3	0	1	3	1	1	0	1	1	1	0	3
Easement or Identified Land Ownership	0.5	1	1	1	1	1	2	3	2	2	3	1	1	2	3	1	2	1	3
Accessible for Construction	0.7	1	1	2	1	1	3	3	3	1	3	2	1	2	3	3	3	2	3
Accessible for Monitoring and O&M	0.7	1	1	2	1	1	3	3	3	1	3	2	1	2	3	3	3	2	3
Ease of Permitting	0.5	3	3	2	1	2	1	3	1	1	2	3	3	2	2	2	2	1	2
Infiltration Possibilities	0.8	3	3	2	0	2	2	1	0	0	1	3	3	0	0	2	2	0	2
Potential for Combined Technologies	0.3	2	2	1	1	1	3	2	1	1	2	2	2	2	0	3	2	1	2
Predictable Flows	0.8	3	3	3	3	3	3	2	2	3	2	3	2	2	2	3	2	3	3
Potential for High Phosphorus Loading	1	1	1	1	1	2	3	3	2	3	2	2	2	3	3	2	1	2	3
Neighborhood Acceptance	0.5	1	1	1	1	1	2	3	3	3	3	1	1	1	2	2	2	1	3
Demonstration Potential	0.7	1	1	1	1	1	2	3	2	1	2	1	1	2	2	2	1	1	3
Downstream Influence	0.8	1	1	1	3	1	3	2	1	3	1	1	1	2	3	2	1	1	3
Total Score:	-	15.6	15.6	13.4	11.5	14.8	23.8	22.8	15.3	16	20.8	17	15.8	15.5	18.9	20.4	17.3	11.5	25.7

Ranking Code:
1 = Least Favorable
3 = Most Favorable
0 = Disqualified Category

Color/Shading Code:
- 5 Sites Recommended for Baseline Monitoring
- 5 of the 10 Sites Outlined in QAPP, No Baseline Monitoring
- Sites Disqualified due to Low Ranking

Other criteria used for site selection are:

- Easement or identified land ownership at the site (necessary to avoid construction delays and acquisition costs);
- Accessible for construction;
- Accessible for pre and post monitoring and Operation & Maintenance (O&M) (for continued proper operation, and to minimize long-term costs);
- Ease of permitting (to keep the project schedule on track);
- Potential for combined technologies;
- Neighborhood acceptance; and
- Demonstration potential (at a location easily viewed or accessed by the general public).

Sites assigned the ranking of zero (0) in any particular category are listed in Table 2.2. Also listed is an explanation as to why the zero ranking was assigned to that particular site/category.

Table 2.2 Explanation of Zero Disqualifiers within SSM

Ranking Category	Site	Reason for Assigning Zero
Capacity for Head loss	K-Mart (NW Parking Lot)	Outfall below grade & at wetland elevation
	Phalen Street (end-of-pipe)	Outfall observed with standing water, essentially at GW elevation
	Simon-Willard Road	Outfall at wetland elevation
Infiltration Possibilities	Cowdrey Lane	Outfall discharges directly to stream
	K-Mart (NW Parking Lot)	Outfall at wetland elevation
	Knowlton Drive	Outfall discharges directly to stream
	Phalen Street (both locations)	Outfall at elevation of GW
	Simon-Willard Road	Outfall at wetland elevation
Potential for Combined Technologies	Phalen Street (BMP in Road)	No reasonable combination of P-removal technologies exist for in-road applications

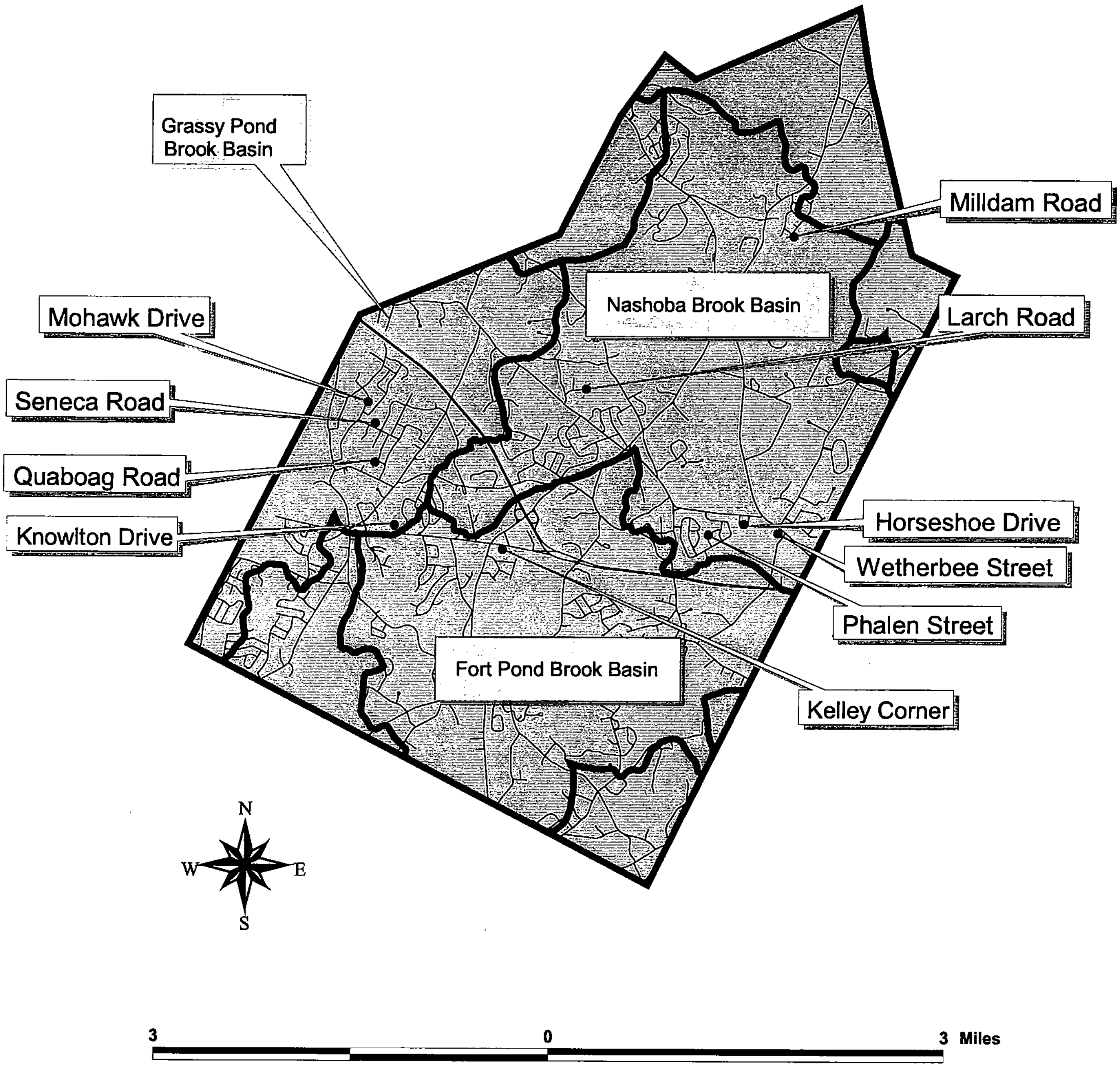
2.3 FINAL TEN SITES

Figure 2.2 displays the location of the ten (10) stormwater outfalls recommended for additional evaluation in accordance with the procedures within the QAPP. The ten (10) sites are:

1. Horseshoe Drive
2. Kelley Corner
3. Knowlton Drive
4. Larch Road
5. Milldam Road
6. Mohawk Drive
7. Phalen Street
8. Quaboag Road
9. Seneca Road
10. Wetherbee Street

Photographs of the ten (10) outfall sites can be found in Appendix A of this report.

Figure 2.2 Ten Selected Outfalls



3. OUTFALL SITE DESCRIPTIONS

The following outfall site descriptions provide details related to the location, pipe size, receiving waters, and drainage area of each outfall site. The advantages and disadvantages of installing a structural BMP at each site are listed and expanded upon.

Descriptions of these sites were formulated following the four rounds of screening, which occurred on November 7, 2001, January 9, 2002, January 25, 2002 and March 14, 2002. General weather conditions prior to and during the site visits were documented. These weather conditions were observed in the field and referenced from the National Weather Service (NWS) as follows:

- November 7, 2001 – No precipitation, temperature in the middle 50's. Approximately .25-inches of precipitation occurred on November 5th. Prior to that, very dry conditions have persisted since Spring 2001.
- January 9, 2002 – No precipitation, seasonably cold with temperatures in the 30's. Approximately 2 inches of snowcover is common across town. Previous rainfall occurred on January 6th, when almost 0.5-inches was recorded (Bedford NWS monitoring station).
- January 25, 2002 – No precipitation. Mild with temperatures in the mid forties. Dry conditions with no rainfall over previous three days.
- March 14, 2002 – No precipitation. Very mild with temperatures in the sixties. Approximately 0.5-inches of rain recorded on March 10th (Bedford NWS monitoring station).

3.1 HORSESHOE DRIVE

Horseshoe Drive is located in east Acton, close to the intersection of Concord Road and Great Road (Route 2A). Horseshoe Drive intersects Concord Road at both ends, wrapping in a semi-oval shape similar to that of a horseshoe. At the western intersection of Horseshoe Drive and Concord Road, drainage from the "Poets' Corner" residential village collects in a small, shallow pond located behind two homes that abut the intersection. The pond's area is estimated to be approximately 0.15 acres. Leaf litter and silt have accumulated in the pond over time. The continued accumulation of leaf litter and silt was confirmed by a resident of one of the adjoining properties, who contributed the following information:

- Hydraulically, the pond responds to short duration, heavy rainfall events by filling rapidly, followed by quickly draining back to baseflow depth.
- A noticeable reduction of wetland plants has occurred in the pond over recent years.
- Highest level of flooding observed when the pond overflowed its banks and the flood level approached the foundation of the house on Horseshoe Drive.

Overflow from the pond drains east along Concord Road where it discharges to Nashoba Brook, located approximately 750 feet away. Base flow is observed under dry conditions, which indicates high groundwater in the area.

The drainage basin that contributes stormwater flow to the pond is primarily residential. Many medium sized, well-maintained residential lawns are located within the pond's drainage basin. Stormwater flow primarily originates from impermeable roads, driveways, roofs, and saturated yards. High potential exists for significant phosphorus loading to the pond and, in turn, to Nashoba Brook due to the lawn care activities of homeowners.

Characteristics of the Horseshoe Drive site that are advantageous to this project include:

- Large residential area contributing stormwater, with the potential for high phosphorus loading;
- Numerous possibilities for altering or adding to current pond structure to enhance nutrient removal;
- Potential for combined technologies upstream of the pond;
- Potential for the upstream enhancement of the stormwater quality entering Nashoba Brook (relatively direct drainage channel from the pond outfall to Nashoba Brook exists);
- Potential for enhancement of pond landscape, thereby providing a good relationship between neighborhood residents and the Town; and
- Easy access for construction and O & M equipment.

3.2 KELLEY CORNER

Kelley Corner encompasses the commercial intersection of Massachusetts Avenue (Route 111) and Main Street (Route 27). Businesses in the area include K-Mart, Roche Brothers Grocery, McDonalds and several auto repair shops. The primary sources for stormwater runoff include the impermeable parking lots, roads, and roofs of these businesses. Some residential runoff from Kelley Road and Beverly Road also contributes to stormwater flow.

The potential for significant phosphorus loading exists at this location due to the contribution of stormwater from commercial, and, to some extent, residential land uses. Studies differ in concluding how significant phosphorus loading may be from commercial land use. Most studies indicate that residential land use exports higher concentrations of total phosphorus as compared to commercial land use, yet the potential for a greater net export of total phosphorus exists at Kelley Corner when compared to a smaller residential drainage area. This is due to the relatively large impermeable area, which, overall, produces more runoff than many of the residential outfall locations evaluated in this report.

A total of three drainage outfalls are located within the location identified as Kelley Corner. These three outfalls are described as follows:

- A 24-inch outfall pipe oriented parallel to Massachusetts Avenue discharges into a drainage channel in front of a daycare center along Massachusetts Avenue (across Massachusetts Avenue from Roche Brothers).
- An 8-inch outfall pipe discharges diagonally from Massachusetts Avenue into the same drainage channel, at approximately the same location as the 24-inch outfall pipe.
- An 8-inch outfall pipe enters at a 90-degree angle to the drainage ditch, draining the parking lot of the daycare center. This pipe is located approximately 20 feet to the east of the other two outfall pipes.

The drainage channel that accepts stormwater from these three outfall pipes is a rocky channel located approximately 30 feet south of, and running parallel to, Massachusetts Avenue. The channel flows east toward a wetland area, which ultimately discharges to Fort Pond Brook.

One drawback to the Kelley Corner site is that discharged stormwater drains to a natural wetland. Wetlands are commonly considered to be nutrient sinks during the growing season, therefore acting as natural stormwater BMPs.

Characteristics of the Kelley Corner site that are advantageous to this project include:

- Extensive commercial drainage area, which may prove to export a significant net amount of total phosphorus;
- Excellent location for a community demonstration project;
- Few, if any, land ownership complications – adjacent Town easement may be used for structural BMP site; and
- Installing a structural BMP would take advantage of treating stormwater flow from one of the few highly commercialized areas in the Town.

3.3 KNOWLTON DRIVE

Knowlton Drive is located in west Acton, between Massachusetts Avenue and Joseph Reed Lane. A 36-inch outfall pipe discharges directly to Fort Pond Brook, just north of Massachusetts Avenue. The outfall discharges stormwater from the residential area to the east of Knowlton Drive, including catch basins along Joseph Reed Lane, Deacon Hunt Drive, Captain Brown Lane, and Captain Forbush Lane. The area is residential, with many medium sized, well-maintained yards. Stormwater flow in the area primarily consists of runoff from impervious roads, driveways, roofs, and saturated yards. Significant phosphorus loading due to lawn care activity is likely in this area.

Drawbacks to this area include limited access to the outfall location and the short distance/minimal elevation change from the outfall location to Fort Pond Brook. Flooding of Fort Pond Brook would likely impact any BMP constructed at the current outfall location. Limited potential exists for a BMP to be installed upstream of the outfall, close to the start of the 36-inch drainage pipe (near Joseph Reed Lane).

Characteristics of the Knowlton Drive site that are advantageous to this project include:

- Large residential area contributing stormwater, with the potential for high phosphorus loading; and
- Direct downstream impact due to discharge to Fort Pond Brook.

3.4 LARCH ROAD

Larch Road is a small residential road located off Evergreen Road in central Acton. Two pipes, a 12-inch pipe and a 24-inch pipe extend out of a headwall on the east side of Larch Road. The 24-inch pipe runs under Larch Road, parallel to Evergreen Road, while the 12-inch pipe drains the catch basins on Larch Road. A concrete diversion culvert inlet on the west side of Larch Road collects surface water from a rocky drainage channel. This water flows under Larch Road through the 24-inch pipe. From the east side of the Larch Road culvert, water flows out of the outfall pipes into a drainage channel that runs parallel to Evergreen Road. The drainage channel eventually discharges into a large wetland located approximately 300 feet downstream. The wetland ultimately flows into Nashoba Brook.

The contributing drainage area to this site primarily consists of mixed residential lots and woods. A significant amount of phosphorus export is not likely at this site due to the relatively small fraction of maintained residential land as compared to the extensive amount of forest in the area.

Positive attributes to the Larch Road site include little to no land ownership or space restrictions, adequate capacity for head loss, and ease of accessibility. Drawbacks include the potential for only medium to low phosphorus loading along with the eventual flow of outfall waters into wetland areas, which typically act as nutrient sinks during the growing season.

Characteristics of the Larch Road site that are advantageous to this project include:

- Few restrictions on land area and ownership;
- Easy site accessibility;
- Adequate capacity for head loss; and
- Plenty of room available for a structural BMP.

3.5 MILLDAM ROAD

Milldam Road is a residential cul-de-sac located in north Acton. Modern homes located on medium sized residential lots abut Milldam Road and the adjacent streets. Stormwater flow primarily consists of runoff from streets, driveways, roofs and saturated yards.

The stormwater outfall evaluated is located between #4 and #5 Milldam Road. The outfall is a debris cluttered concrete sluiceway located adjacent to the driveway of house #5. The outfall drainage basin is quite small, accepting flow from approximately 10 catch basins on Milldam Road, Kate Drive, and Sawmill Road. Flow from the outfall drains into the wooded backyards of #4 and #5 Milldam Road, where it ultimately enters Nashoba Brook, located approximately 200 feet to the east.

Although there is a potential for moderate phosphorus loading from lawn maintenance activities, space at the site is limited due to the close proximity of the outfall to surrounding homes and driveways. In addition, land ownership complications would likely impact efforts to implement a structural BMP at this location.

Characteristics of the Milldam Road site that are advantageous to this project include:

- Potential for moderate phosphorus loading due to lawn care activities;
- Accessible for construction and O & M equipment; and
- Potential for a relatively direct enhancement of stormwater entering Nashoba Brook (a minor amount of buffer currently exists between the outfall and Nashoba Brook).

3.6 MOHAWK DRIVE

Mohawk Drive is a residential road in west Acton located between Central Street and Nashoba Road. Medium sized, well-maintained residential parcels abut Mohawk Drive.

The stormwater outfall evaluated is located on the east side of Mohawk Drive, between #13 and #15 Mohawk Drive. The outfall is a 24-inch pipe that is half filled with debris. The outfall discharges stormwater from approximately six catch basins along Mohawk Drive, in addition to water from a drainage channel on the west side of Mohawk Drive. The drainage channel on the west side of the road accepts water from residential land to the west of Mohawk Drive. Stormwater flowing from the outfall enters forest land behind houses #13 and #14, where it ultimately flows into a small wetland. The wetland drains to Fort Pond Brook, which is located approximately 1,500 feet to the south of the outfall location.

Overall, phosphorus loading potential at this location is only moderate due to the limited drainage area, which consists primarily of mixed residential land and some forest land. Accessibility to the outfall is partially hindered by woods and by private property.

Characteristics of the Mohawk Drive site that are advantageous to this project include:

- Moderate potential for phosphorus loading; and
- Suitable area available for a structural BMP.

3.7 PHALEN STREET

Phalen Street is located in the "Poets' Corner" residential neighborhood of east Acton. Many medium sized, well-maintained residential lots are located in the "Poets' Corner" area. Stormwater flow in the area primarily originates from impervious roads, roofs, driveways, and saturated runoff from yards. Groundwater appears to be high due to the year-round presence of standing and/or flowing water in the surface drainage channels.

The outfall evaluated is located on an easement to the west of #10 Phalen Street. The outfall consists of a 12-inch, partially submerged concrete pipe. A significant drainage area collects and drains to this outfall location. Significant phosphorus loading is likely due to the lawn care activities of homeowners within the large drainage basin.

Stormwater from the outfall flows through a drainage channel behind #10 Phalen Street, where it merges with a second drainage channel that contains flow from other sections of "Poets' Corner". The stormwater is then routed into a grated 24-inch pipe which outlets to the pond on Horseshoe Drive (Horseshoe Drive Site). Ultimately, drainage from "Poets' Corner" flows to Nashoba Brook.

Several disadvantages of the Phalen Street site include limited space at the site due to the close proximity of the outfall to surrounding homes and driveways, high groundwater levels, and little to no capacity for head loss.

Characteristics of the Phalen Street site that are advantageous to this project include:

- Large residential area contributing stormwater, with the potential for high phosphorus loading; and
- Potential for addressing and improving drainage concerns in the area.

3.8 QUABOAG ROAD

Quaboag Road is a residential street extending between Agawam Road and Seneca Road in east Acton. Like Mohawk Drive, Quaboag Road has many medium sized, well-maintained residential lots. Stormwater flow in the area primarily originates from impervious roads, roofs, driveways, and saturated runoff from yards.

The outfall evaluated on Quaboag Road is located on an easement to the south of #36 Quaboag Road. The outlet pipe is covered by a significant amount of silt, debris, and leaf litter. The outfall drains several catch basins and low-lying areas along Quaboag Road. Water from the outfall flows into a stagnant drainage pond behind house #36. The pond currently has no outlet. The homeowner at #36 Quaboag Road mentioned that the Town was considering alleviating flooding and drainage problems at the pond by installing a pipe to route a portion of the water in the pond to a wetland, which is also located behind house #36. The wetland area ultimately drains to Fort Pond Brook.

Phosphorus loading potential at this site is only moderate. Even though the primary runoff is residential, the drainage area is not as large as the other sites that were evaluated. Land ownership complications and high groundwater levels are disadvantages for constructing a structural BMP at this location.

Characteristics of the Quaboag Road site that are advantageous to this project include:

- Potential for concurrently resolving drainage issues in the neighborhood;
- Easy access for construction and O & M equipment; and
- Potential for enhancement of pond landscape.

3.9 SENECA ROAD

Located in the same neighborhood as Mohawk Drive and Quaboag Road, Seneca Road is a residential road with medium sized, well-maintained residential lots. Seneca Road connects Agawam Road to Mohawk Drive. Stormwater flow in the area primarily originates from impervious roads, roofs, driveways, and runoff from saturated yards.

The evaluated outfall is located between #9 and #11 Seneca Road, approximately at the midpoint of the road. Drainage pipes for Seneca Road tie into a culvert that connects the wetland at the northerly side of the road to the wetland located at the southerly side of the road. Stormwater entering the wetland eventually flows into Fort Pond Brook.

Outflow from the culvert is a combination of high groundwater, stormwater, and outflow from the wetland. Room for implementing a structural BMP exists at the culvert location, yet phosphorus loading may be relatively low. A mix of ground water, outflow from the wetland, and stormwater from a small residential area is not likely to contain significant concentrations of total phosphorus. Non-structural BMPs may be best suited for this area.

Characteristics of the Seneca Road site that are advantageous to this project include:

- Adequate room for implementing a structural BMP; and
- Good accessibility for O & M and construction equipment.

3.10 WETHERBEE STREET

Wetherbee Street is located in east Acton, running from the high traffic commercial area along Route 2A (Great Road) south to Route 2 (Massachusetts Avenue). Restaurants, shops, businesses, and residential parcels are located within this drainage area. Roads, parking lots and rooftops of these commercial and residential parcels are the primary sources of stormwater runoff.

The outfall lies just south of the intersection of Wetherbee Street and Route 2A. Stormwater from parking lots and residential areas located northeast of Route 2A is routed to an 18-inch outfall pipe. Residential roads contributing flow to the outfall include Azalea Road, Bayberry Road, and Myrtle Drive. Stormwater exiting the outfall on Wetherbee Street is routed directly to Nashoba Brook, located approximately 30 feet downstream of the outfall. A recently maintained earthen swale conveys stormwater from the outfall pipe to Nashoba Brook.

Two potential locations for a structural BMP exist at this location:

- The outfall pipe close to Nashoba Brook; and
- The overgrown drainage channel located between the Burger King parking lot and D'Angelo's Restaurant on Route 2A.

A high potential for significant phosphorus loading exists at this site. Fertilized lawns (commercial and residential), parking lots and roadways are all potential sources of phosphorus. The capability to enhance stormwater that directly enters Nashoba Brook provides additional incentive for further evaluation of this outfall location.

Characteristics of the Wetherbee Street site that are advantageous to this project include:

- High potential for significant phosphorus loading;
- Adequate room and head loss capacity for implementing a structural BMP;
- A BMP along Wetherbee Street would enhance the quality of stormwater, which currently flows (relatively unhindered) into Nashoba Brook; and
- Excellent location for a demonstration project.

3.11 SUMMARY OF SITE CHARACTERISTICS

Table 3.1 contains an informative breakdown of pertinent characteristics for each of the ten (10) outfalls evaluated. The size of each drainage basin is described as small, medium or large in relation to other basins within the Town based on visual estimates from the Town drainage maps. The ten (10) outfalls are a good representative sample of typical outfalls throughout the Town, with varying land uses, drainage basin areas, pipe diameters, outfall locations, and watershed impacts.

Table 3.1 Summary of Site Characteristics

Site Location	Typical Land Use in Drainage Basin	Relative Size of Drainage Basin (S/M/L)	Outfall Diameter(s)	Impact on Receiving Stream (Low, Medium, High)	Watershed District
Horseshoe Drive	Residential	Large	30" pipe to drainage channel	High	Nashoba Brook
Kelley Corner	Commercial	Large	24", 8", 8"	Low (drains to wetland)	Fort Pond Brook
Knowlton Drive	Residential	Medium	36"	High	Grassy Pond Brook
Larch Road	Forest/Residential	Medium	24", 12"	Low (drains to wetland)	Nashoba Brook
Milldam Road	Residential	Small	Concrete Sluiceway	Medium (buffered by woods)	Nashoba Brook
Mohawk	Residential	Medium	24"	Low	Grassy Pond Brook
Phalen Street	Residential	Large	12"	Medium (buffered by pond)	Nashoba Brook
Quaboag Road	Residential	Small	18" (covered)	Low (drains to pond)	Grassy Pond Brook
Seneca Road	Residential/ Wetland	Medium	24"	Low (drains to wetland)	Grassy Pond Brook
Wetherbee Street	Commercial and Residential	Medium	18"	High	Grassy Pond Brook

4. BASELINE MONITORING SITES

In accordance with Task A2 of the MADEP Scope of Services, up to five (5) locations must be selected for baseline monitoring. The sampling program design, which includes methods, parameters, and plans for sampling the five (5) outfalls, is included within the QAPP. This section lists the sampling locations chosen and justifies the rationale behind choosing these sites.

The five (5) sites selected from the initial ten (10) summarized in Table 3 are:

1. Horseshoe Drive
2. Kelley Corner
3. Larch Road
4. Quaboag Road
5. Wetherbee Street

Table 4.1 details important characteristics of each of the five (5) sites chosen for sampling. The final five (5) sites reflect a comprehensive cross-section of land uses, drainage basin sizes, outfall diameters, downstream impacts and watersheds.

Information provided in Table 4.1 is a focused equivalent of Table 3.1. Table 4.1 allows for easy comparisons between specific characteristics of the sampling locations.

Table 4.1 Summary of Site Characteristics (Five Final Sites)

Site Location	Typical Land Use in Drainage Basin	Relative Size of Drainage Basin (S/M/L)	Outfall Diameter(s)	Impact on Receiving Stream (Low, Medium, High)	Watershed District
Horseshoe Drive	Residential	Large	30" pipe to drainage channel	High	Nashoba Brook
Kelley Corner	Commercial	Large	24", 8", 8"	Low (drains to wetland)	Fort Pond Brook
Larch Road	Forest/Residential	Medium	24", 12"	Low (drains to wetland)	Nashoba Brook
Quaboag Road	Residential	Small	18" (covered)	Low (drains to pond)	Grassy Pond Brook
Wetherbee Street	Commercial and Residential	Medium	18"	High	Grassy Pond Brook

Appendix B of this report contains maps that depict the location of each of the five (5) outfalls, along with adjacent streams and roads. These maps show shaded areas that approximate the drainage area/system that contributes flow to each of the outfall locations. Upon completion of digitizing the Town drainage maps, a much more precise delineation of the each drainage basin will be provided. The digitized drainage maps will be used to determine runoff flows for the design of the structural BMPs

The BMP SSM (Table 2.1) shows that these five (5) sites were allocated the highest point total, illustrating the desirability of the sites for BMP installation. Three of the sites, Horseshoe Drive, Kelley Corner, and Wetherbee Street, were considered to have the best potential for a structural BMP among the sites listed in the SSM.

The sites with potential to provide valuable sampling data were utilized in the selection process. The remaining two sites, Larch Road and Quaboag Road, were chosen for two reasons; (1) they were ranked number four and five respectively on the SSM and (2) they contain unique characteristics that may provide valuable sampling data comparisons to the other sites listed in Table 5.1.

The unique characteristic of Larch Road is the large influence of forested land on runoff. The majority of the sites evaluated lie in either residential or commercialized sections of Town. Larch Road contains stormwater from residential streets, yet much of the land in its drainage basin is forested. Sampling results from the Larch Road outfall may provide an indication of how stormwater quality is affected by a residential neighborhood that is part of a watershed containing a significant forested area.

The unique characteristic of the Quaboag Road outfall is its relatively small drainage area. Many of the other outfalls evaluated discharge stormwater from multiple streets or entire residential communities. The Quaboag Road outfall only discharges stormwater collected in several catch basins along Quaboag Road. Sampling results from this outfall can provide a comparison between stormwater parameters in small versus large drainage basins.

When comparing the five (5) sites, it can be noted that a good variation of land uses and drainage basin sizes were chosen. Variation of these site characteristics will be valuable when analyzing sampling data. Choosing a wide variety of sites will provide less of a chance that sampling results will be similar for all of the sites.

5. GENERAL FINDINGS

The primary function of the existing drainage systems is to provide drainage for wet areas and to convey surface runoff away from areas of human use such as homes, yards, and streets. Much of the drainage system in the Town was constructed through the programs of the Works Progress Administration (WPA) in the 1930's. During this period the most direct drain route to unbuildable land was generally used without much regard for the impacts on the receiving waters. Only recently in the State's construction history have stormwater detention basins and other structures been incorporated into common use to protect the receiving waters from the direct impacts of stormwater (sediment, nutrients, pollutants, etc.).

Many of the structural BMPs outlined in technical fact sheets and reports by the DEP, the EPA, and the Center for Watershed Protection, or studies conducted by colleges and universities tend to focus on treating stormwater produced from new developments. This project is aimed at retrofitting structural BMPs to existing drainage systems. The challenge lies in the limited available space near outfalls, the limited access for construction or O & M equipment, the lack of available head loss between an outfall and its receiving water (since outfalls tend to be placed at the edge of streams and wetlands), and the limited number of potential technologies available for retrofitting.

The selection of drainage outfalls suitable for this demonstration project was unexpectedly limited given the substantial number of drainage structures currently existing in the Town. The older, 1930 vintage drains are generally located at or close to the groundwater level. Additionally, many of these older systems are channeling existing streams instead of providing passage for surface runoff. Since the drainage structures are in or near normal groundwater elevation and, because of the highly variable seasonal flows, the probability that sampling results will be conclusive may be reduced.

These difficulties, however, can be overcome. Looking beyond typical "programmed" applications of new BMPs is important to the success of this project. For example, retrofitting an existing pond structure to allow for greater detainment of stormwater may produce significant results. This not only allows for more suspended solids to settle, it may also allow for additional infiltration. Changing a stormwater detention pond into a constructed wetland is also a possible retrofit. Additions such as sediment forebays in front of constructed wetlands can further enhance pollutant and nutrient removals. Many of these possibilities are currently being considered in the search for successful BMPs to install in Acton.

To keep track of applicable BMPs for this project and to determine which BMPs are most suitable, a BMP technology ranking matrix is currently being constructed. A preliminary version of this matrix was used to aid in the selection of potential BMP sites. The matrix is included in Appendix C. When the final two sites are determined, the fact sheets will be employed either to determine a suitable BMP for the site, or, if a BMP has already been chosen, to see if that particular BMP ranks highly as compared to other BMPs. Until sampling results are obtained from the five (5) sites and sampling analyses are performed, selecting a particular structural BMP is not feasible.

6. SUMMARY AND CONCLUSIONS

The Town employed an iterative and methodical approach in identifying the most practical locations for installing structural BMPs that demonstrate the potential to remove phosphorus from stormwater. This process has resulted in the selection of five (5) sites for further monitoring:

1. Horseshoe Drive
2. Kelley Corner
3. Larch Road
4. Quaboag Road
5. Wetherbee Street

The final five (5) sites reflect a comprehensive cross-section of land uses, drainage basin sizes, outfall diameters, downstream impacts and watersheds that were specifically selected to provide a measure of assurance that the sampling program will detect phosphorus in suitable quantities for continuation of the watershed trading program.

The Town appreciates the guidance provided by the MADEP's project team with the grant program, QAPP submittal, and continued support throughout this project.

The sampling and monitoring program will begin upon the MADEP's review and approval of this report and the QAPP.

APPENDIX A
Outfall Site Photographs

Horseshoe Drive Site

Kelley Corner Site

Knowlton Drive Site

Larch Road Site

Milldam Road Site

Mohawk Drive Site

Phalen Street Site

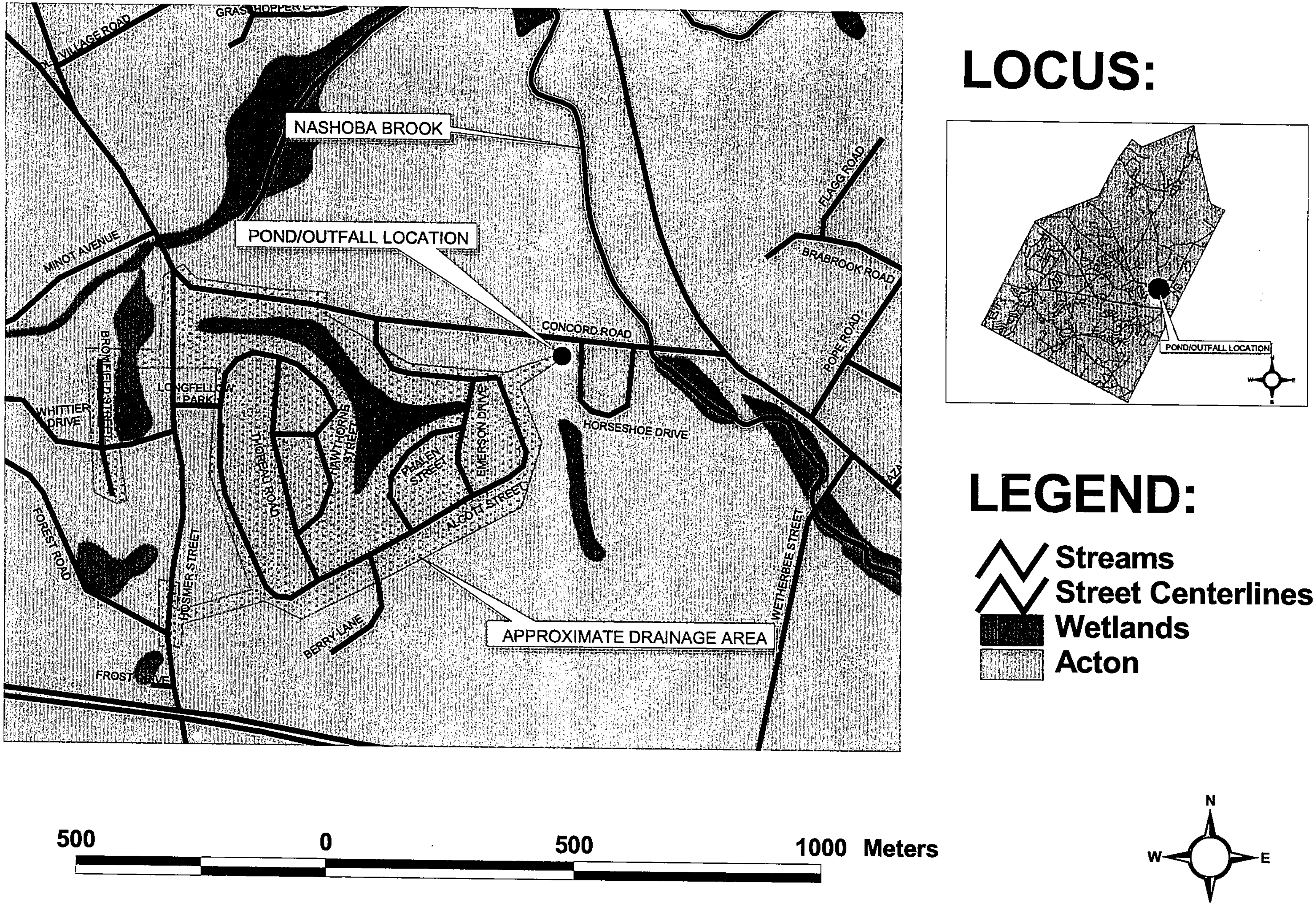
Quaboag Road Site

Seneca Road Site

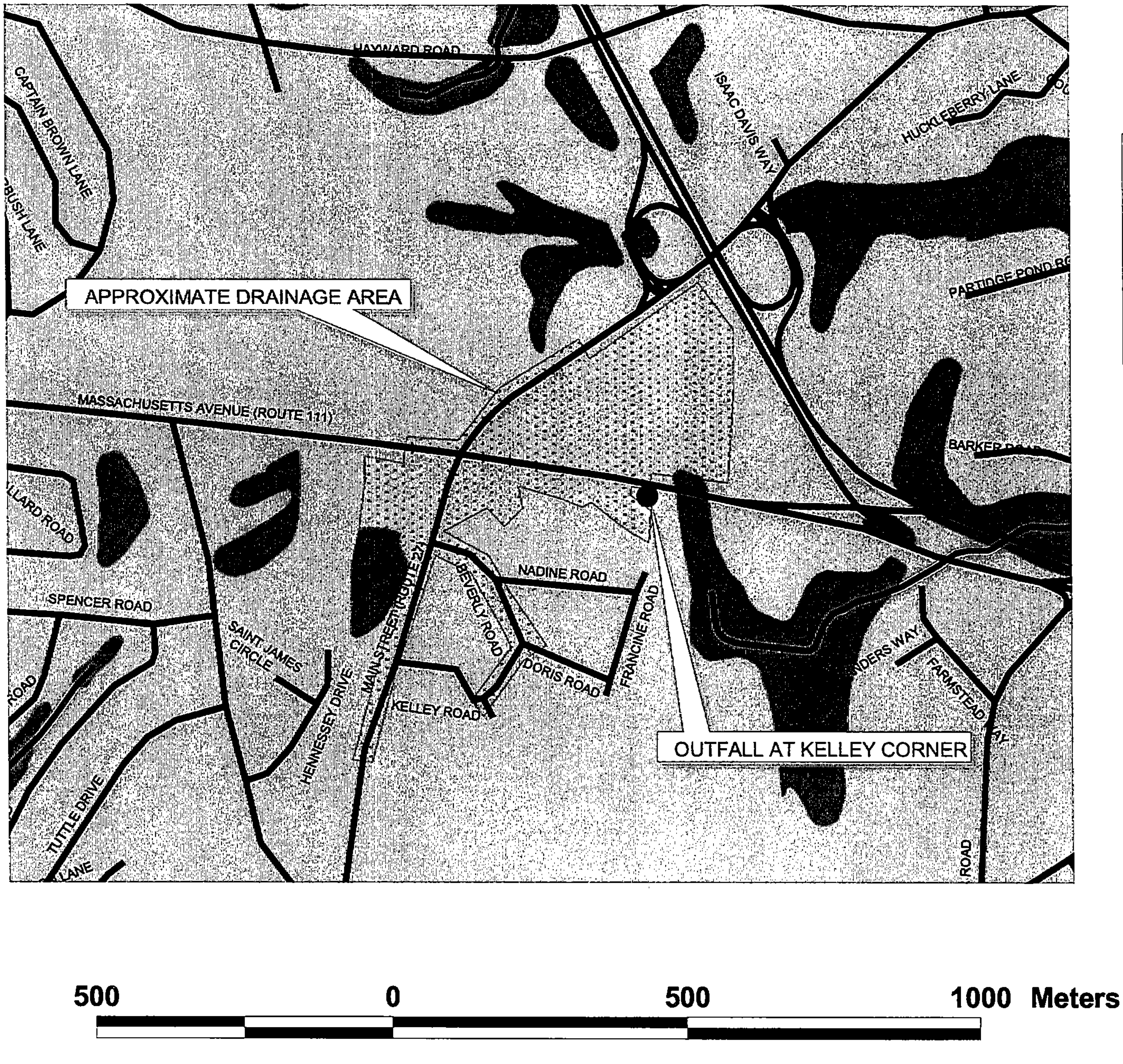
Wetherbee Street Site

APPENDIX B
Outfall Location Maps

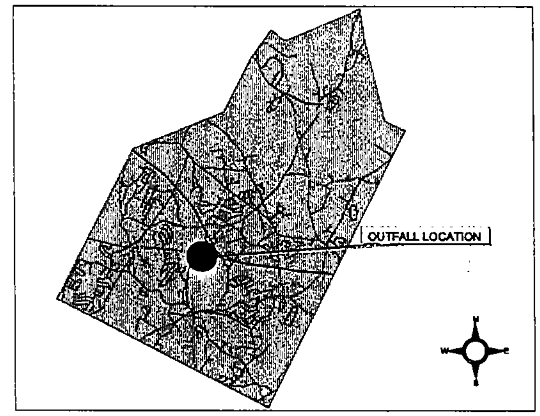
HORSESHOE DRIVE DRAINAGE



KELLEY CORNER DRAINAGE

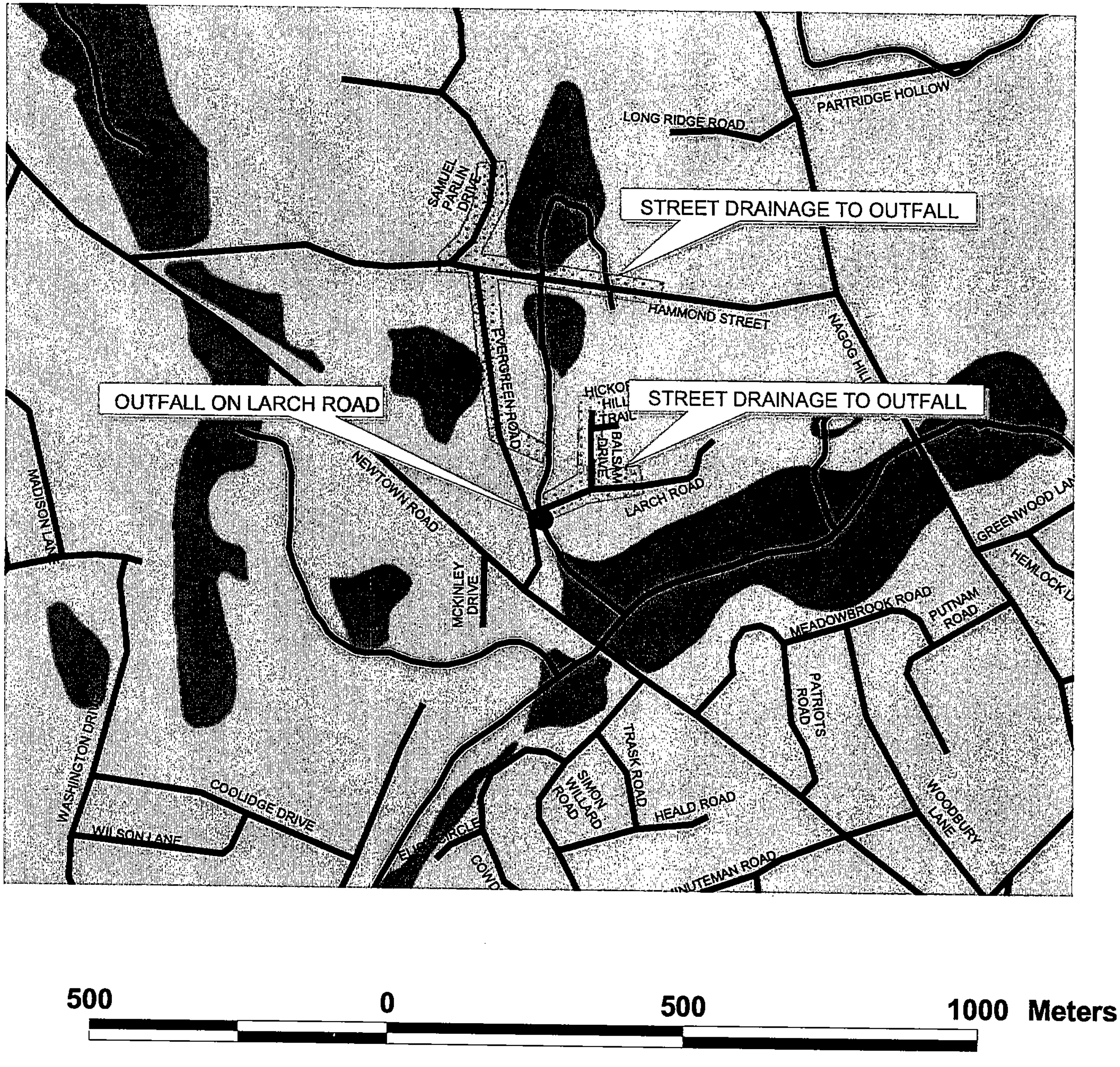


LOCUS:

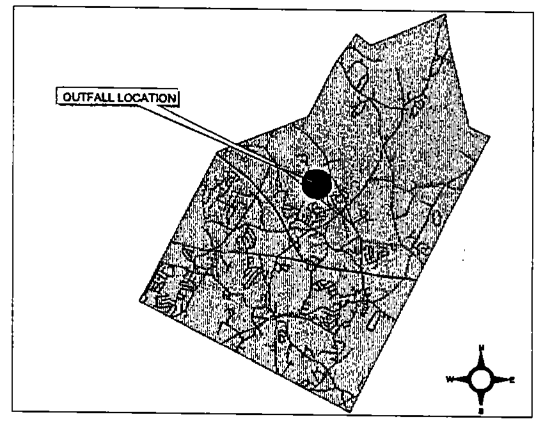


LEGEND:

LARCH ROAD DRAINAGE



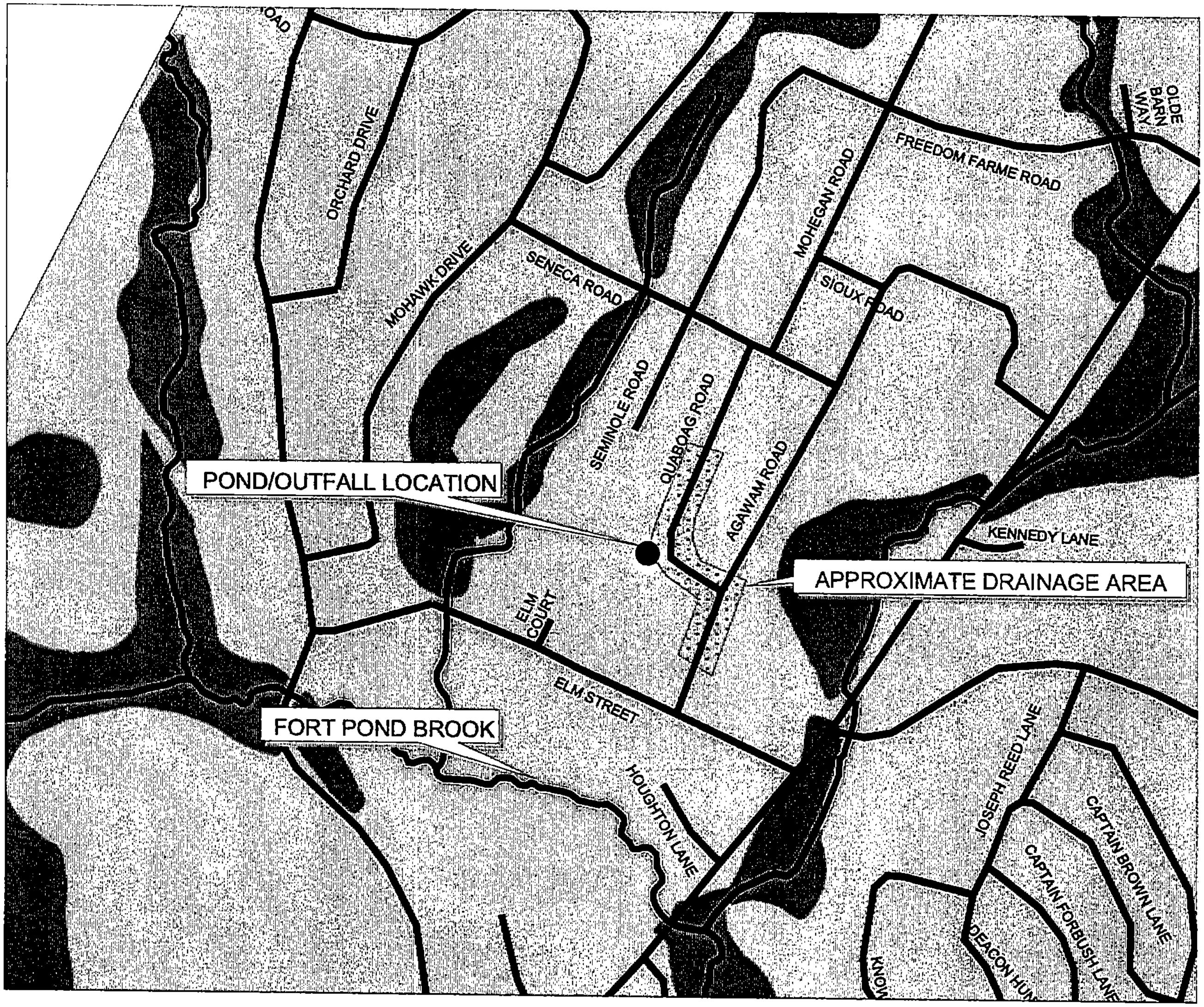
LOCUS:



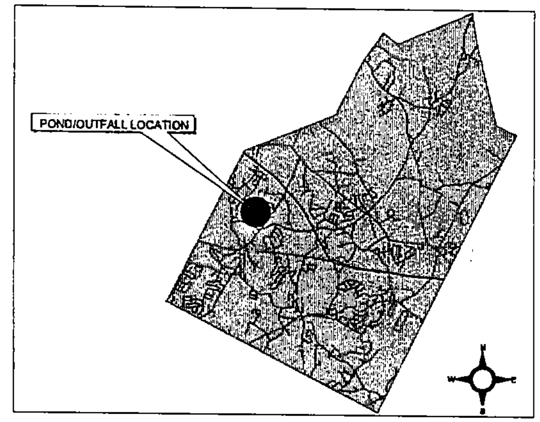
LEGEND:

- Streams
- Street Centerlines
- Wetlands
- Acton

QUABOAG ROAD DRAINAGE



LOCUS:



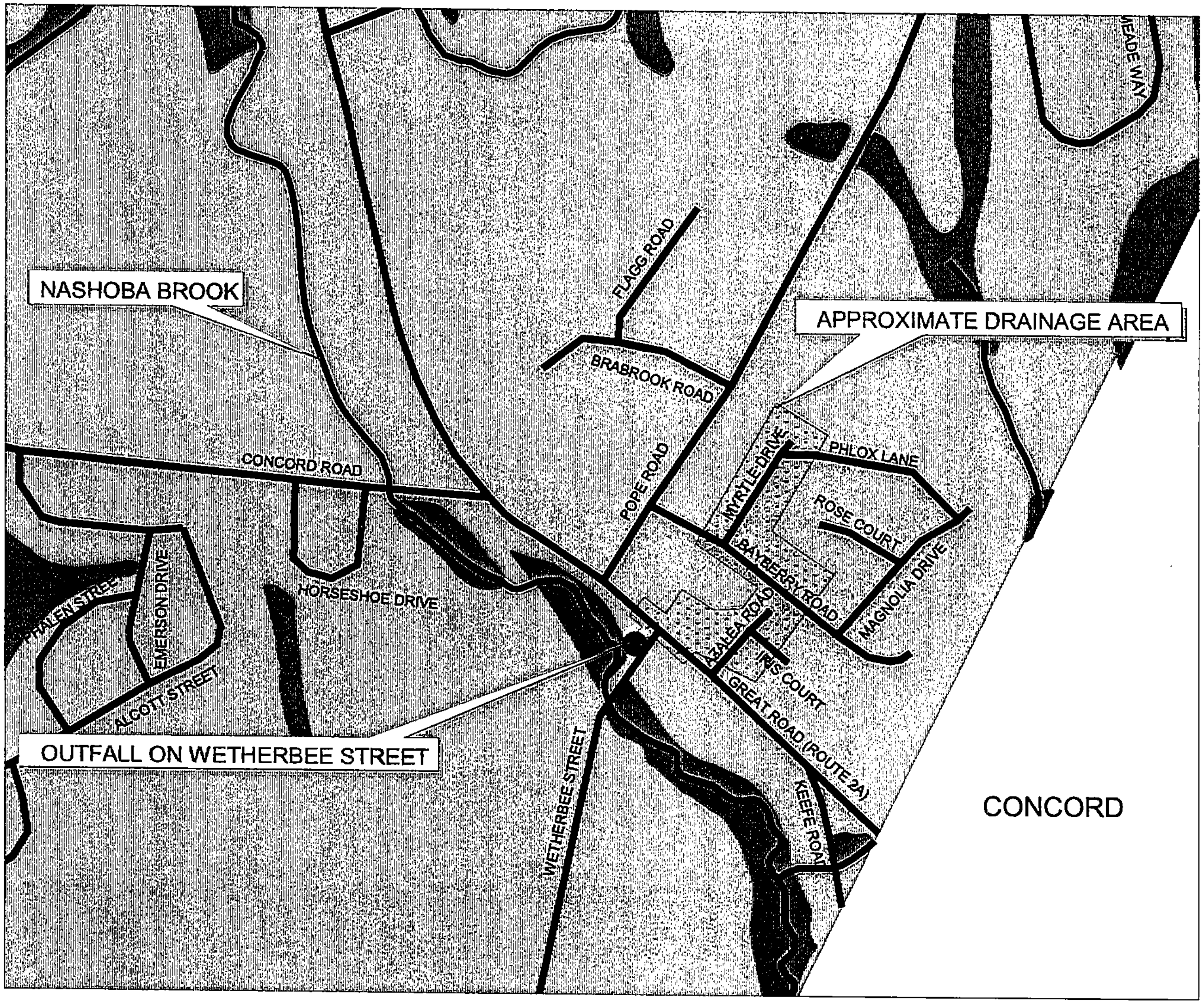
LEGEND:

- Streams
- Street Centerlines
- Wetlands
- Acton

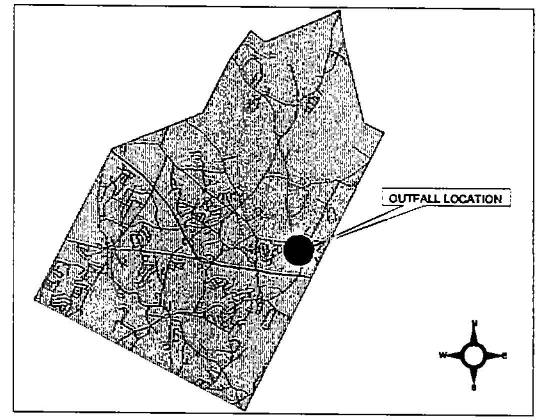
500 0 500 1000 Meters

N W E

WETHERBEE STREET DRAINAGE



LOCUS:



LEGEND:

- Streams
- Street Centerlines
- Wetlands
- Acton

500 0 500 1000 Meters

N
W E
S

APPENDIX C
BMP Technology Ranking Matrix

WORKING BMP RANKING MATRIX

Ranking Category	Category Multiplier (0.1-1X)	Dry Extended Detention Ponds	Grassed Swales	Infiltration Technologies	Modular System- StormTreat	Modular System - StormFilter	Sand & Organic Filters	Storm Water Wetlands (New)	Stormwater Wetland (Modifying Existing)	Wet Detention Ponds (New)	Wet Detention Ponds (Modify Existing)	Wet Swales
		BMP Technology										
319 Project Applicability	1	2	3	1	3	3	2	3	3	2	3	3
Ease of Installation by Town Forces	0.7	3	3	2	2	2	2	1	2	2	2	3
Ease of Design (Pre-designed?)	0.8	3	3	2	3	3	2	1	2	2	3	3
Ease of Maintenance	0.8	3	3	1	1	1	1	2	2	2	3	3
Ease of Pre and Post Monitoring	0.7	1	3	1	3	3	3	3	3	3	3	3
Phosphorus Reduction Potential	1	1	2	3	3	2	2	3	3	2	2	2
Installation History in Massachusetts	0.2	3	3	1	3	1	1	3	3	2	2	3
Capital/Installation Costs	0.7	3	3	2	1	1	2	1	2	2	3	2
O & M Cost	0.8	3	3	1	1	1	2	2	2	2	2	3
End of Pipe Solution	0.7	3	2	3	3	3	3	3	3	3	3	2
Aesthetics and Property Value Impacts	0.6	1	3	1	3	3	3	2	2	2	3	2
Level of Pretreatment Requirement	0.6	3	3	1	2	2	3	3	3	3	3	3
Expected Life Span	0.6	3	3	1	3	3	3	3	3	3	3	3
EPA/ Regulatory Acceptance	0.6	3	3	1	3	2	2	3	3	2	2	2
Level of Soil Exploration	0.6	1	2	1	3	3	3	1	2	1	2	1
Potential for Mosquito/Pest Nuisance	0.6	1	2	1	2	3	3	1	1	1	1	1
Total Score:	-	25	30.1	16.6	26.5	25.1	25.4	24	26.8	23.4	27.9	27